SimAnt™

MAXIS

The Electronic Ant Colony

SIMANT™

THE ELECTRONIC ANT COLONY

Program

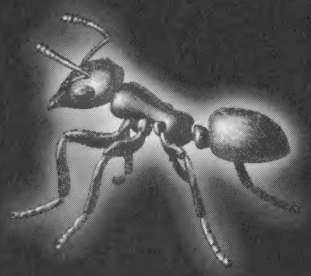
WILL WRIGHT

JUSTIN McCORMICK

Manual

MICHAEL BREMER

SIMANT



SIMANT

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SIMANT

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SIMANT

PART 1
SIMANT — PLAYING THE GAME

Ants are so much like human beings as to be an embarrassment. They farm fungus, raise aphids as livestock, launch armies into war, use chemical sprays to alarm and confuse enemies, capture slaves, engage in child labor, and exchange information ceaselessly. They do everything but watch television.

— Lewis Thomas, The Lives of a Cell

SimAnt

EXTENDED TABLE OF CONTENTS

PART 1: SIMANT — PLAYING THE GAME

INTRODUCTION

Ants are simple, even stupid individuals. But an ant colony, through the interaction of a great number of ants, displays an amazing skill at survival, and a noticeable level of intelligence.

In SimAnt, you are the intelligence of an ant colony. The individual ants are like the individual brain cells of your being. You will hop into and out of individual ants, using them as tools. Many of your ants will die, including at times the one you are inhabiting. But the death of individual ants will not greatly affect you as a colony. In fact, one of your ants dying will hurt you about as much as a human trimming a fingernail.

THE OBJECT(S) OF THE GAME

There are three ways to play SimAnt: Quick Games, Full Games and Experimental Games.

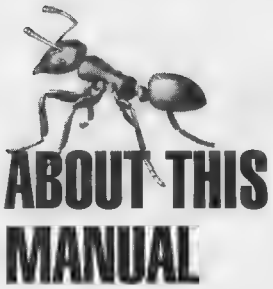
In Quick Games you are a black ant colony competing with a red ant colony for food and territory. Your goal is to defeat the red ants and take over your home turf—the local patch of ground in the backyard. Your task will be complicated by marauding spiders, voracious ant lions, torrential rains, crushing human feet and merciless lawn mowers.

In Full Games you must take over the entire backyard section by section, then take over the house and drive out the humans. In addition to hordes of red ants and other pests, you will face the chemical death of insecticides.

In Experimental Games, you are a human playing and experimenting with ants. Your tools let you build walls and barriers to run ants through mazes; add food; add ants; dig or fill in holes; test ants' reactions to various trail-marking and alarm chemicals; and play with insecticide.

In addition, there is a Tutorial mode that walks you through the basics of life as an ant.

Very large ants are giANT.



ABOUT THIS MANUAL

This manual is written in four parts:

Part 1: SimAnt — Playing the Game explains the SimAnt program: getting it running on your computer; using the menus and windows; playing the game; and basic strategies. It includes a Tutorial and complete Reference. Part One also features some factual information on real ants, where and when it is necessary to understand the game.

Part 2: Real Ants — Backyard Background is in-depth information on real ants, ant colonies, and social insects. Reading this section will give you the background you need to play SimAnt to the best of your abilities.

Part 3: Beyond Ants — Antcillary Materials is a philosophical/literary approach to ants. It contains quotes, myths, fables and legends, fictional books and movies about ants, and covers a wide range of topics from their uses by humans as food and in medicine to their role as "Mascot" of the artificial-life branch of computer science.

Part 4: Glossary, Bibliography and Index defines many of the words used in Parts One and Two, gives a listing of nonfiction books about ants for people of all ages, and helps you locate topics quickly. Any words in any part of this manual that are followed by an asterisk [*] will be found in the Glossary.

This manual was written to cover a number of computer platforms. Everything in this manual will relate to most computers, but there will occasionally be slight differences. Included with this manual is a separate machine-specific Addendum/Quick Start Guide that will cover the details that change from computer to computer, like: installing and starting the program, mice, keyboards, and window controls.

The windows in SimAnt will differ a little in size, shape and color depending on the computer and monitor used. The screen shots used in this manual are primarily from the high-resolution color Macintosh and IBM VGA versions. These should look enough like the screen on your computer so that you won't be confused. There will definitely be some

Ants that don't go to school are truANT.

differences on computers that run in low-resolution (320 x 200). Any differences will be pointed out in the machine-specific Addendum/Quick Start Guide.

SOFTWARE TOYS AND SYSTEM SIMULATIONS

SimAnt isn't exactly a game—it's what we call a "Software Toy." Toys, by definition, are more flexible and open-ended than games.

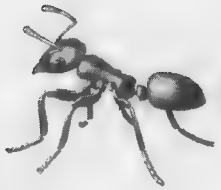
As an example, compare a game, tennis, with a toy, a ball. In every tennis game, there is one way to begin, one goal to pursue, and one way to end. There are infinite variations in the middle, but they all start the same way, chase the same goal, and end the same way. A ball is more flexible—there are more things you can do with it. With the ball, you can play tennis. You can play catch. You can throw it at someone. You can bounce it. You can make up a hundred different games using the ball. Besides games, there are other things you can do with a ball. You can paint it, use it to plug a leaky roof, or just contemplate its roundness.

In SimAnt, the "toy" is a backyard filled with ant colonies.

When you play with SimAnt, or any of our Software Toys, don't limit yourself to trying to "win." Play with it. Experiment. Try new things. Just have fun.

There are many types of toys. SimAnt, like SimCity® and SimEarth™ before it, is a SYSTEM SIMULATION toy. In a system simulation, we provide you with a set of RULES and TOOLS that describe, create and control a system. In the case of SimAnt, the system is an ant colony. Part of the challenge of playing with a System Simulation toy is to figure out how the system works and take control of it. As master of the system you are free to use the Tools to create and control an unlimited number of systems (in this case, ant colonies) within the framework provided by the Rules.

An ant that is not close is distANT.



In SimAnt, the Rules to learn are based on ant biology and behavior, including:

Communication: ants have very sophisticated communication methods.
Nest building: ants dig for safety and temperature control, and to make brood chambers for the young.
Foraging: ants must find food and return it home safely.
Brood care: ants tend and protect their eggs, larvae and pupae.
Altruism: ants must protect the queen and brood at all costs.
Territoriality: ants defend their home turf from all competitors.
Cooperative behavior: groups of ants working together can bring home large pieces of food and defeat much larger enemies.

The Tools provide you with the ability to grow, lead, and experiment with an ant colony:

Begin with one queen and one worker and grow to a colony of a thousand ants.
Dig underground nests that can accommodate and protect your ants.
Search for food to keep your colony alive and growing.
Defend your colony and food sources from other ant colonies.

But the most important Tool of all is the simulator itself. Test your knowledge, plans, theories and ideas as you watch your colonies develop or decline. Experiment with the ants and test their intelligence and adaptability to various conditions.

A hip ant in a radiator is coolANT.

GETTING STARTED

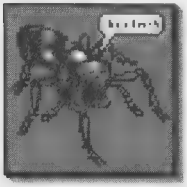
INSTALLATION

Depending on your computer, you may or may not need to install SimAnt before playing. See the machine-specific Addendum/Quick Start Guide for your computer for installation instructions.

STARTING THE PROGRAM

Once again, see the machine-specific Addendum/Quick Start Guide for your computer.

THE ON-SCREEN TUTORIAL



An on-screen Tutorial is built into SimAnt. There is also an off-screen Tutorial in the next section of this manual. Some people prefer their tutorials on-screen, other prefer them off. Most people don't prefer them at all. There is slightly different information in each of the tutorials, so playing through both won't be a waste of time.

To start the on-screen Tutorial, click on the Tutorial button in the Select Game Window.

TUTORIAL — GOING FOR A BUGGY RIDE

BEFORE YOU BEGIN...

Before playing SimAnt there are a few things you'll want to know:

BASIC STRATEGY

In a Quick Game, you lead your ants to food, defend your nest and queen, and destroy the red colony. You win when you kill the red queen. In a Full Game, you do the same, plus breed new queens, send them out to make new colonies, and take over the whole house and yard. You win when you eliminate all the red colonies in the yard and you drive the humans out of the house. In an Experimental Game, you do whatever you want. You win when you decide you've won.

DYING

Ants don't care much about individualism. Even to each other they all look alike. When an ant dies, it's no big deal (even to the ant that dies). It's the safety of the queen and whole colony that counts. The death of any ant other than the queen—even you—is not important.

Because of this, in SimAnt, unlike in most other games, dying is not losing. It's not the end of the world, much less the end of the game. You just lose a little time and energy.

REPRODUCTION

In the ant world, very few ants can reproduce. Most ants—all the workers and soldiers—are sterile females. Only at certain times are the males and fertile females that can start new colonies produced. The reproductives, called *Breeders* in SimAnt, are large, use up a lot of food, and do no work. Only a colony that stores up enough extra food can afford to make Breeders and reproduce.

An ant that dries up in the sun is a currANT.

OF MICE AND KEYBOARDS

SimAnt is much easier and more fun to play if you have a mouse. If your computer doesn't have one, check in the computer-specific Addendum/Quick Start Guide for information on using menus and for keyboard equivalents to terms like "clicking" and "dragging."

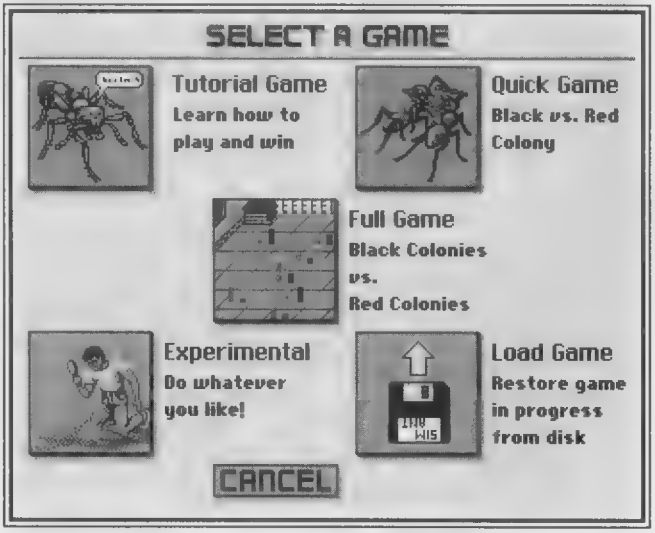
THE GAME IS AFOOT (ALL SIX OF THEM)

STARTING THE PROGRAM

See your machine-specific Addendum/Quick Start Guide for installation and starting instructions.

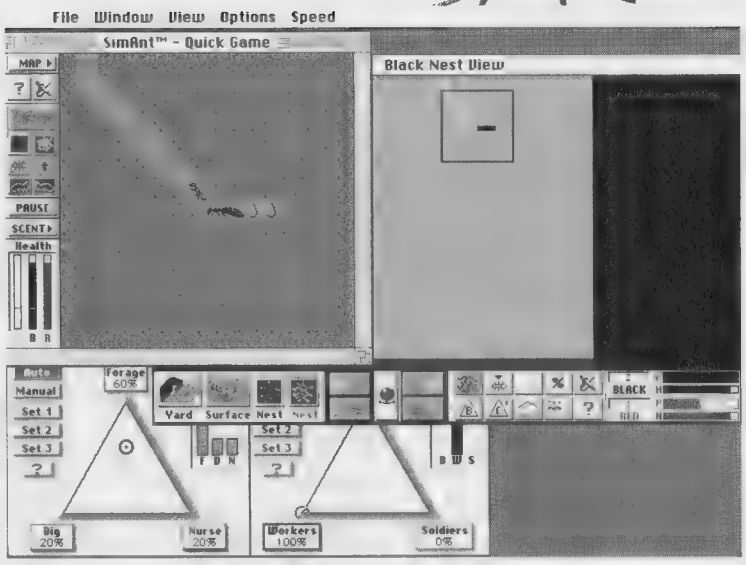
STARTING A NEW GAME

The first thing you will see is the Select A Game Window. Click on Quick Game.



A brave ant is gallANT.

THE *ANTICS* BEGIN



You will now see four windows: the Edit Window (your close-up view), the Map Window (your overall view), the Behavior Control Window (for telling your ants what to do), and the Caste Control Window (for controlling what kind of ants your colony produces). Your screen should look similar to the screen shown, but depending on your computer, may vary a little.

The Edit Window is active and on top. Near the top of the Edit Window is a Message Bar. Keep an eye on it for helpful hints during the game. On the left side of the Edit Window is a control panel with lots of buttons. Click on the PAUSE button to stop the game while we look around.

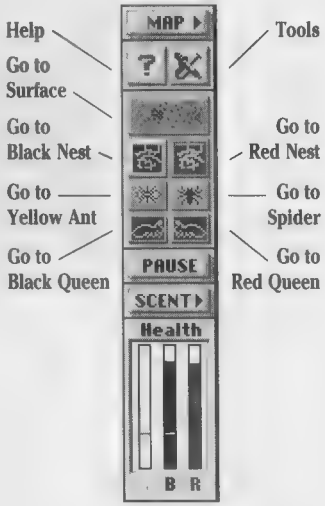
Click and hold on the Help button—the one with a question mark on it. While you hold it down, it displays an explanation of each button on the control panel. Most windows have Help buttons.

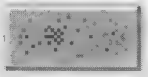
To the right of the Help button is the Tool button. Don't worry about it for now.

I GET AROUND

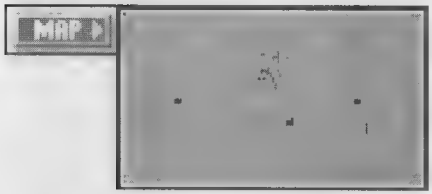
There is a lot of ground to cover, and a number of ways to do it. There are the usual Scroll Bars, Boxes and Arrows, and also a number of buttons that let you jump around quickly.

The buttons below the Help button and above the Pause button each change the view in the Edit Window. Click on them and see what they do. Notice that as the view changes in the Edit Window, it also changes in the Map Window.





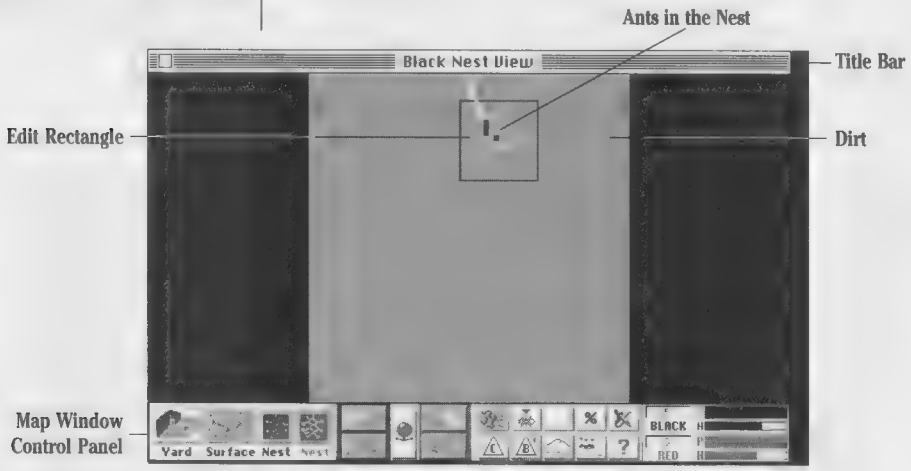
After playing with the buttons, click on the Surface button and we'll look at another way to get around.



Click on the MAP button at the top of the control panel. A tiny map appears. The rectangle in the tiny map outlines the area that shows in the Edit Window. Click all over the tiny map. The rectangle moves to where you click and the Edit Window shows the new area in the rectangle.

THE BIG PICTURE

Open the Map Window, either by clicking on any exposed part of it or by selecting Map in the Windows Menu.



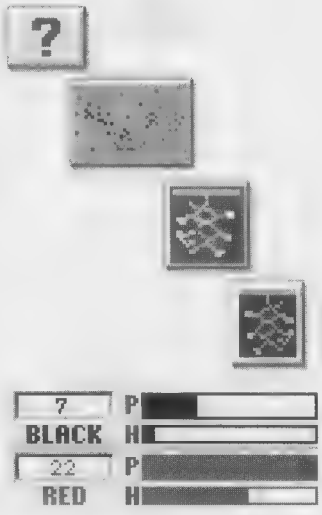
Somewhere in the map is a rectangle that outlines the area shown in the Edit Window. Click on different parts of the map to move the rectangle.

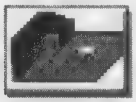
A real fast ant does things in an instANT.

Select Surface from the View Menu. You now see the whole Patch from above. Notice that there are two anthills. These are the entrances to the black and red nests. There are a few other things wandering around, but the only one to worry about right away is the spider.

At the bottom of the window is the Map Window Control Panel. Four of the buttons should look familiar: the Help, Surface, Red Nest and Black Nest buttons. Click and hold on the Help button to see an explanation of everything in the control panel. Click on the other three to see what happens. Notice that as you change the view in the Map Window, the Edit Window changes to match.

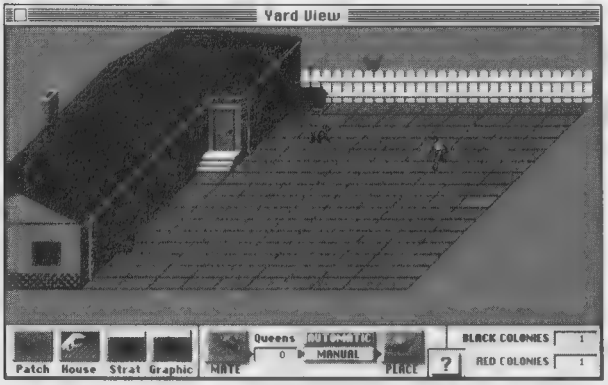
On the right side of the control panel are graphs that tell the population and health for both colonies.





THE BIGGER PICTURE

Click on the Yard button. This is the complete house and yard. Each little square represents one Patch (the entire game area for a Quick Game). The active Patch is blinking.

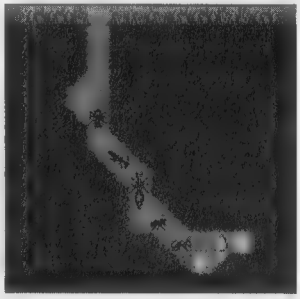


Notice that the control panel has changed. Click on the House button. Inside the house are more patches for your ants to take over (but only in Full Games).

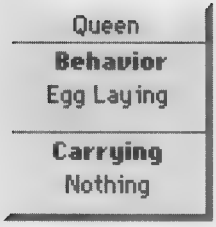
Click on the Patch button to return to the Patch.

MOVE YOUR ANT

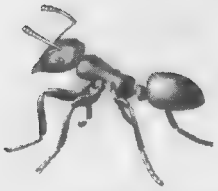
Activate the Edit Window by clicking on it or selecting Edit from the Window Menu. Click on the Yellow Ant button in the control panel. The Edit Window centers on the Yellow Ant. It should be underground. If it isn't, then open the File Menu, select New, click on Quick Game, and click on the PAUSE button.

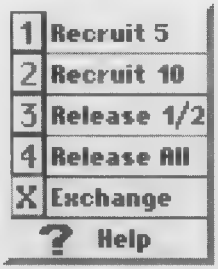


You should now be looking at the black ant nest. The big black ant is the queen. The other ant is the Yellow Ant. If you have a black and white monitor the Yellow Ant will be white, not yellow, but it's still called the Yellow Ant.



Click and hold on the queen. An info window appears telling you what kind of ant she is and what she is doing. This window is available for all ants and brood (eggs, larvae and pupae).





The Yellow Ant is you. Through the Yellow Ant you will lead your colony to victory (or not, as the case may be). Click and hold on the Yellow Ant and a menu appears. This menu helps you lead your colony. We'll explain Recruit, Release and Exchange later. The Help item (question mark) displays info on controlling the Yellow Ant.

To move the Yellow Ant, you don't need the menu. Just click where you want it to go. To make it dig, double-click where you want it to go.

Try it: click to make the Yellow Ant move around in the tunnel, and double-click in the dirt to make it dig. If you climbed out of the tunnel to the surface, click in the center of the anthill to go back down.

Note: When a game is paused, it doesn't completely stop—it is in a "single-step" mode. Everything stops until you move the Yellow Ant. While it is moving, the game is in action: the other ants, spiders, and insects move. Pausing the game gives you time to think, but no protection from enemies.

SURFACE, SURFACE

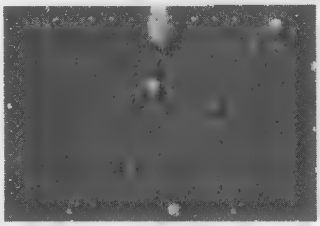
Scroll the Edit Window so the grass at the surface is showing at the top of the window. Double-click on the grass. The Yellow Ant will dig its way to the top, and the Edit Window will show the surface above the nest.

An ant that floats is buoyANT.

DANGER

Once you are on the surface, you risk being eaten by the spider. If you are eaten, you will be reborn back in the nest as a new Yellow Ant, so all you lose is time and energy. But since dying is a hassle, try to avoid it.

Other dangers that might catch you are ant lion traps, human feet and the dreaded lawn mower. And people talk about how bad a dog's life is.

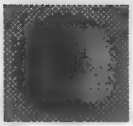


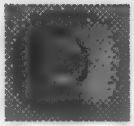
FEED ME

The most important thing for you to do now is to find food for your colony. Food is shown in SimAnt as green balls. On a black and white monitor, they won't be green, but they will be balls.

To find food, you can scroll around the Edit Window or look at the Map Window. Pick a window, find some food, then return to the Yellow Ant in the Edit Window.

Unpause the game by clicking on the Pause button or selecting Unpause from the Speed Menu so your queen will be able to lay some eggs and the eggs will have time to hatch into adult ants.





Start moving your Yellow Ant towards the food by clicking where you want it to go. Watch out for the spider, and don't cross any ant lion traps. Both are deadly.

Once you get to the food, double-click on a food ball to pick it up. You can only hold one ball at a time, so you better call for help.

CALL OUT THE CAVALRY

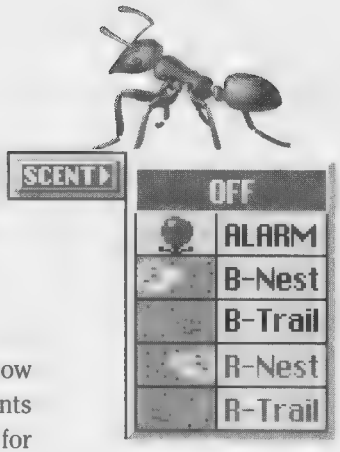
Click and hold on the Yellow Ant to see the Yellow Ant Menu. Slide the pointer to highlight Recruit 5, and release the pointer. Five black ants will rush to the Yellow Ant, ready for action. Once they arrive, click and hold on the Yellow Ant to see the Yellow Ant Menu, then highlight Release All and release the pointer. The ants will grab some food and rush back to the nest with it.

I SMELL FOOTSTEPS

AntFact: As ants bring food home to their nests, they leave a chemical trail. Other ants of the colony can smell the trail and know it leads to food. They also find their nests by smell.

In SimAnt, when an ant carries food back to its colony, it automatically leaves a scent trail along the way. To check it out, click and hold on the SCENT button, slide the pointer to highlight B-Trail, and release it. Then, as you make your way back to the nest with your load of food, notice the trail you leave.

An overweight ant is abundANT.



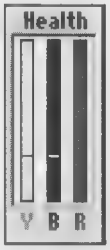
When you have the display of scents on, you can see these trail markers as well as colony scents. When the screen gets too cluttered, you can turn the Scent display off. The ants will still smell the scents, but you won't see them.

DELIVERY

Once you return to your nest, double-click where you want the Yellow Ant to put the food down. You don't have to go back for more—your ants will follow the trail and bring back all the food. You should now look for more food, and show it to your ants.

DEPARTM*ANT* OF HEALTH AND WELFARE

A big part of playing SimAnt is keeping your colony and the Yellow Ant healthy. Health is based on how much food you find. The healthier your ants are, the better their odds in battles with red ants. In SimAnt, health directly relates to hunger. If the ants have enough food, they are healthy.



At the bottom of the Edit Window Control Panel is the Health Graph. It shows the health levels of the Yellow Ant, the black colony and the red colony. The higher the bars, the better the health.

FINE DINING?

The more you move the Yellow Ant, the more energy it uses and the more it needs to eat. When the Yellow Ant is hungry and you double-click on food, it eats it instead of picking it up. If there is no food around, a nearby black ant will feed you. If there is no food or black ants nearby, recruit some to feed you.

Ants share their food with each other. Even after they've eaten it. When an ant feeds the Yellow Ant, it's not a pretty sight—that's why we put in an animated sequence of it.

> ***AntFact: Ants have two stomachs, one to digest food for themselves, and one to hold food to share with the whole colony. The extra stomach is called the crop. (And when there are thousands of ants in a colony, that's a lot of crop.)***

GOOD BEHAVIOR

As leader of your colony, you have to do more than point to food. You have to make job assignments. Select Behavior from the Window Menu to open the Behavior Control Window.

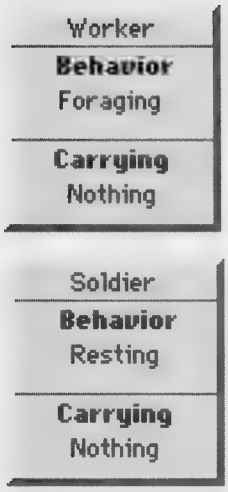
A fertilized queen just glows. She's radiANT.

There are three basic things that your ants must do: forage (find food and bring it back), dig (enlarge the nest), and nurse (take care of the queen and her young). The computer will automatically assign these jobs to your ants, but if you do it yourself, you can make better use of your resources than the computer can.

Each of the three activities is at the corner of a triangle. The triangle is like a joystick controller. Somewhere in the triangle is a "knob" that you can click and drag. The closer you drag the knob to a corner, the more ants will perform that job. The percentages of ants at each job are displayed in the three corners. Click on the percentage boxes to toggle to a display of the actual number of ants at each job.

MEET THE RED MENACE

All the time we've been puttering around looking for food and reading tutorials, the evil red queen has been cranking out eggs that have hatched and grown to fill the ranks of the bad guys. They've been gathering food, digging out their nest and raising soldiers. Time to rumble.



In a real game, you'll want to be sneakier, but for the sake of this tutorial, let's try a frontal attack. Before you begin your campaign, Exchange your Yellow Ant into a soldier; you'll have better odds in fights.

First, pause the game and find a soldier—if you can. Soldiers have larger heads than workers, but may still be difficult to pick out just by looking at them. Click and hold on any ant to bring up a little information window that tells, among other things, whether the ant is a worker, soldier, or other type of ant.

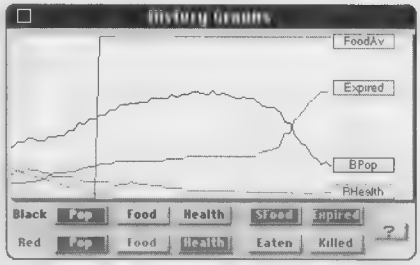
Once you have a soldier picked out, click and hold on the Yellow Ant and slide the pointer to **Exchange** and release. Now click on the soldier to exchange bodies with the Yellow Ant.

Start your Yellow Ant towards the enemy nest. On the way, click and hold on the Yellow Ant, then slide the pointer to **Recruit 10**. Do it again, if you have enough ants. As you reach enemy territory, individual red and black ants will pair up in life-and-death battles. As the leader, you may want to avoid direct contact with the enemy. If you lose a fight, the Yellow Ant will die and be reborn back at the nest. The black ants will wander away, and you will have to start the campaign over again.

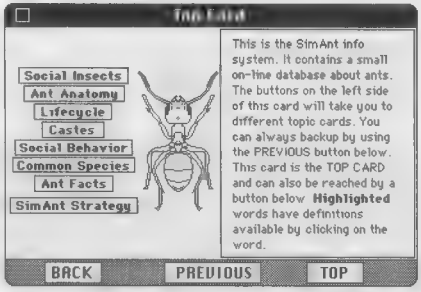
If you stay alive, and your troops outnumber the enemy, lead them down into the red nest and attack the queen. If not, don't worry about it. You can always try again.

OTHER WINDOWS

While we're here, let's check out a couple other windows that are helpful in playing SimAnt.

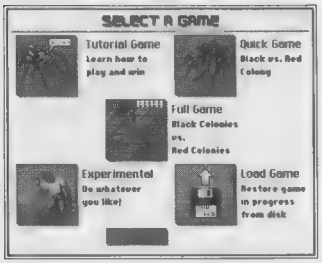


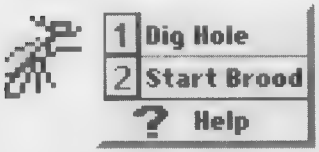
The History Window tracks the rise and fall of ant population, health and welfare. Click on the buttons to see the different graphs, click and hold on the Help Button for an on-screen explanation of all the buttons, and click and hold in the graph area to see the current number value for each graph.



The Info Window is a tutorial on real ants. It is set up like a cardfile with hot links between cards. See the Info Window section of the manual for complete details.

FOR THE LONG RUN





Now we'll check out the features that are found only in Full Games. First, select New Game from the File (or Project) menu, then click on Full Game.

QUEEN FOR A DAY

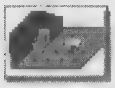
The Yellow Ant is a new queen, just landed from the mating flight. She has to find some soft ground, dig a nest, and start a new colony. First, move her to some clear ground, then click and hold on the Yellow Queen to see a menu of things the queen can do. Slide the pointer to highlight **Dig Hole.**

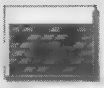
The Yellow Queen will dig below the surface. Double-click to have the Yellow Queen dig a little deeper. Now open the Yellow Queen menu and select **Start Brood.** Her wings will fall off, her hindquarters will extend, and she will begin laying eggs.

The first egg to hatch will become the Yellow Ant. Now play continues as in a Quick Game—for a while. In a full game, once your colony has enough food stored up, you need to produce Breeders—reproductive male and female ants—and spread new colonies around the house and yard.

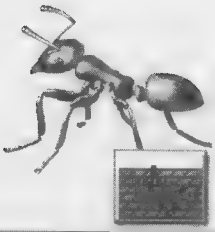
LOADING AN EXISTING GAME

We'll jump forward in time and load a Full Game that has been going on for a while. Select Open (or Load) from the File (or Project) Menu. Load in the saved game called TUTORIAL.ANT. It should be in the default directory or folder. If not, it will be on one of the SimAnt disks.

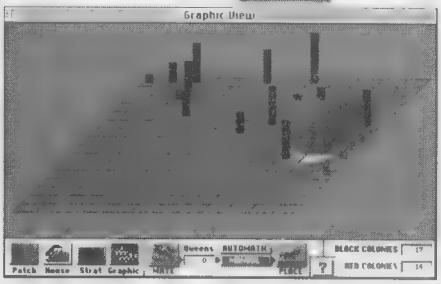




Activate the Map Window, and click on the Yard View button. Next, click on the Strategic View button. This shows which of the Patches are dominated by red ants, which are dominated by black ants, which are still in contention, and which are antless.



Click on the Graphic button. This view shows the relative red and black populations in each Patch.



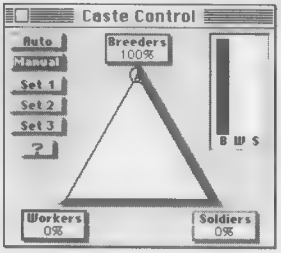
Your goal now is to produce Breeders, send them on their mating flight, and start new colonies.

CASTE PARTY

Select Caste from the Window Menu to activate the Caste Control Window. This window lets you control the types of ants that are born in your colony. It works in the same way as the Behavior Control Window.

For the most part, you will be producing only Workers and Soldiers. Only when it is time to make new colonies and you have the energy to spare should you make reproductive ants.

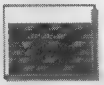
Drag the "knob" to produce 100% Breeders and no Workers or Soldiers. This is a higher percentage of Breeders than you would normally set, since it will drain the colony of energy and leave it with little hope of getting more, but it will help you understand the mating process.



Select the fastest speed in the Speed Menu, and wait until you have a few males and new queens (about seven of each is a good number). Click and hold on the graphs on the right side of the Map Window Control Panel to see a complete population breakdown of ant types in both colonies.

A strange ant is aberrANT.

LET YOUR HEART TAKE FLIGHT



Activate the Map Window and click on the **Strat** button to go to the Strategic View. Look at the center section of the control panel. This is where you control mating.

Notice that the Automatic button is depressed. If you start the mating cycle in "Automatic," the new queens will automatically be placed in different Patches by the computer.

Click on the Manual button so you can place your new queens wherever you want, then click on the Mate button to begin the mating cycle.

After a short while, the number of queens available to start new colonies will appear in the Queens box. Click on the Place button, then click on the Patch where you want to start a new colony. Click on Place again, then on a new Patch until all your queens are placed. You can only place queens on Patches up to three squares in any direction away from the Patch where they were born.

Once all your queens have been placed, double-click on one of the new Patches to take control of the local colony. You can only enter a Patch where there is a black colony or a newly placed queen.

Take some time and move around to a few different Patches and explore the different colonies in the house and yard.

THERE'S PLENTY MORE WHERE THAT CAME FROM

You should now understand the basics of SimAnt. Take some time and play. When you are ready for more, check the Reference section of this manual. It explains all the details, strategies and background you'll need to succeed as an insect. The manual also has a big section on real ants, and some interesting info on ants and humans through the years.

A dependable ant is relIANT.

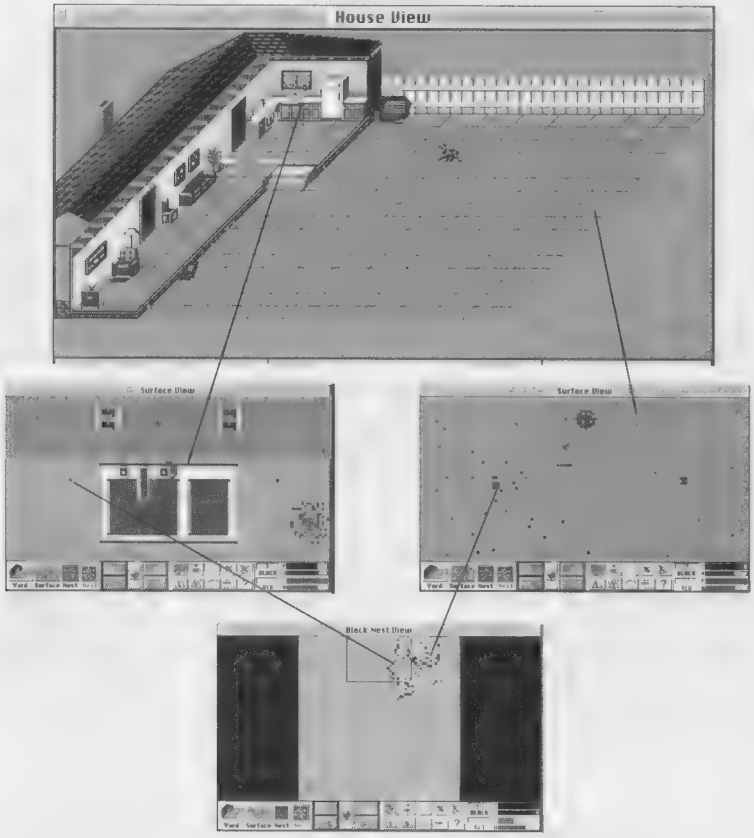
REFERENCE

This section of the manual covers, in detail, every window, button, control, and menu item in SimAnt, explains how the simulator works, and gives strategies for playing. You will get more out of this section if you read/play through the Tutorial section above.

THE BASICS

THE BACKYARD UNIVERSE

SimAnt all takes place in a "universe" that consists of one house and its backyard. The house and yard are divided into 192 sections, or "Patches," each of which can be a battlefield for ants.



A good worker is the queen's servANT.

In a Quick Game, you will only deal with one Patch for the whole game, always outside the house.

In a Full Game, you will play in one Patch at a time, until you can reproduce and spread to other patches, eventually dealing with the entire universe. Even though you spread throughout the whole yard, only one Patch will be active at a time.

Experimental Games are played in only one Patch, and always outside.

YOUR PLACES IN THE BACKYARD

There are three roles you can play in SimAnt: the Game Player, an Ant, and a Human.

AS THE GAME PLAYER

As the game player, you control the computer. You start SimAnt, use the menus to load and save games, arrange the windows on your screen, and set program options and speeds.

AS A HUMAN

In Experimental Games you are a human using various tools to play with and learn about ants.

AS AN ANT

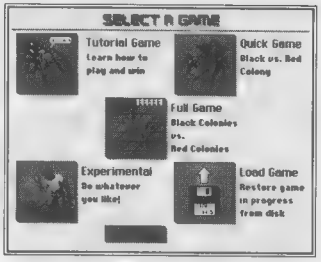
In Quick and Full Games,you are the leader of the black ants. You are responsible for the well-being and survival of the black ant colony. You can sit back and watch, but the red ants will soon eat you out of house and home (literally) unless you intervene and lead your black ants to victory.

As leader of the black ants, you manage your colony in three ways: by controlling the types of ants in your colony with the Caste Control Window; by controlling the behavior of the ants in your colony with the Behavior Control Window; and by setting an example for your ants and leading them to food or into battle as the Yellow Ant.

A freeloading ant is a vagrANT.

TYPES OF GAMES

There are three types of games to be played in SimAnt: Quick Games, Full Games, and Experimental Games.



QUICK GAMES

The object of a Quick Game is to take over a single Patch of the yard and kill the red queen. Quick Games always occur outside—never in the house.

The game starts with the founding of a red and a black colony in a Patch. Each colony has a queen in a small nest that begins to lay eggs. The first black egg that matures becomes the Yellow Ant.

Gather food, defend your nest and queen, breed workers and soldiers, and kick ant. The game ends when one of the queens is killed. If you kill the red queen, you win. If the red ants kill your queen, you lose.

FULL GAMES

The object of a Full Game is to take over the whole house and yard. To win you must eliminate all the red ants and drive out the humans by taking over 70% of the Patches inside the house.

The game starts as a new black queen lands just after her mating flight. She temporarily acts as the Yellow Ant, and you control her with clicks and a pop-up menu until she starts to lay eggs. Using the menu, you must make her dig a small nest and start to lay eggs. The first egg that matures becomes the Yellow Ant.

As in a quick game, you must gather food, defend the nest and queen, breed workers and soldiers and fight the red menace—but you also have to produce Breeders—males and fertile females—and start new colonies. When you have enough energy (food) stored up, you can start producing Breeders and begin your campaign to dominate the backyard universe.

Remember: this first Patch of ground is just a starting point for your conquests: you must think ahead and plan your strategies for multiple Patches, or you might win the battle and lose the war.

You win by taking over the whole house and yard by killing all the red ants and making the humans move out by taking over 70% of the Patches inside the house. You lose when all your queens are killed by your enemies.

You don't have to actually play every one of the 192 Patches to win a game. Colonies that you found will be simulated in the background and will grow until (and unless) you actually enter them.

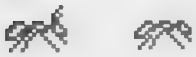
EXPERIMENTAL GAMES

The object of an Experimental Game is to play with ants, using different tools and chemicals to see how they behave in different situations.

In Experimental Games, food does not automatically appear. You have complete control over all food in the experiment.

There is no winning or losing in Experimental Games—at least not for you; but considering the tools you have to work with, quite a number of electronic ants will probably consider themselves losers.

THE YELLOW ANT PART 1



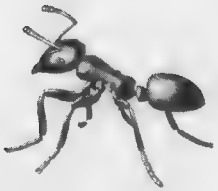
When some ants find a large source of food or discover an enemy that is too big or dangerous to handle alone, they "recruit" help. These ants, called initiators*, initiate action and spur other ants to action.

The Yellow Ant is the initiator ant of the black colony. It is your way of leading and teaching your ants by example. It is the ant that you personally "inhabit" and control.

The Yellow Ant is always a member of the black colony. It is yellow to make it easier to see. On computers with black and white monitors it won't actually be yellow, but it will be marked in some way to make it easy to distinguish from the others in your colony.

You can switch from ant to ant, making any live, mature adult ant in the black colony the Yellow Ant (this includes the queen, but not eggs, larvae, pupae or dead ants).

An ant that plays xylophone is a vibrANT.



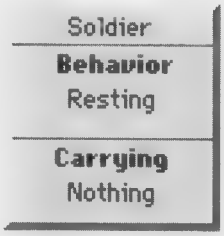
You can control the Yellow Ant in either the Edit Window (the up-close view) or the Map Window (the overall view). Besides leading the ants to food, the Yellow Ant can recruit other ants to follow it, and release them to follow their duties as set forth in the Behavior Control Window.

> ***Antfact: One of the more important communication skills for ants is "recruitment." Ants often find food or enemies that are too large for one ant to handle. By recruiting help, and working in groups, ants have become very efficient competitors.***

The Yellow Ant can be killed, but it's no big deal. With ants, the colony is the most important thing: the death of individual ants means very little. If the Yellow Ant dies, it is instantly reborn back in the black nest. All you lose is a little time.

TYPES OF ANTS: CASTES AND BROOD

There are a number of different castes, or types of ants, that inhabit your colony. Each has its strengths, weaknesses and purpose in colony life. One of your tasks as leader of the black ants is to control how many of each type of ant is born with the Caste Control Window. And, as the Yellow Ant, there are times when it is better to become one type of ant than another.



In the Edit Window, clicking and holding on any ant (except the Yellow Ant) brings up a small information window about the ant. It tells the type of ant (worker, soldier, queen, male, fertile female, egg, larva, or pupa), its behavior mode, its load (if it is carrying anything), and its current health.

A detailed real-world description of these types of ants is found in Part Two of this manual, but here is a quick explanation of these ants and how they behave in SimAnt.

Worker
Behavior
Foraging
Carrying
Nothing

WORKERS

Workers are generally the most numerous ants in any colony. As their name states, they do most of the work around the colony, which consists of: finding food; taking care of the queen and the young; enlarging, maintaining, and defending the nest; and attacking enemies. Workers are sterile females, and cannot mate or lay eggs.

You will want to have more workers than other ants, especially when the colony is small and young.

AntFact: It is the workers, not the queen, that are the real rulers of the ant colony. The workers have more mobility and bigger brains. Don't let the human usage of "queen" and "worker" fool you.

Soldier
Behavior
Resting
Carrying
Nothing

SOLDIERS

Soldiers are just big workers. They do pretty much the same tasks as workers (except generally not nursing), but they are bigger and stronger.

Since soldiers are bigger, they require more food than workers, and are less efficient. Don't make too many soldiers when your colony is small: if there is a shortage of food, many of your soldiers will starve. Once the colony grows, and you have a lot of food stored, you will want lots of soldiers to attack the red ants.

It is a good idea to make the Yellow Ant a soldier. It will have better odds in fights against red ants.

AntFact: Even though soldiers have bigger heads than workers, their brains are no bigger. Their big heads are filled with muscles that control their heavy, powerful mandibles.

To search an anthill you need a warrANT.

QUEENS

Queens are your treasure. If your queen dies, your colony dies and you lose the game. If you kill the red queen, you win.

Queen
Behavior
Egg Laying
Carrying
Nothing

Queens, once a colony is started, do very little but lay eggs. They are fed and their eggs are tended by workers. In SimAnt there can only be one queen per colony.

The main reason to make the Yellow Ant a queen is to move her deeper into the nest to make her harder for the red ants to find.

NEW QUEENS

New Queens are fertile females. They do very little work around the colony. Their only purpose is to found new colonies.

New Queen
Behavior
Pre-Flight
Carrying
Nothing

New queens are large, and since they don't work, they are very expensive to feed and care for. You shouldn't make any new queens until your colony is big enough and rich enough (in food) to support them. If you are playing a Quick Game, you shouldn't waste any time or energy on them at all.

MALES

Males are large and lazy and only have one purpose in life: fertilizing new queens.

Male
Behavior
Pre-Flight
Carrying
Nothing

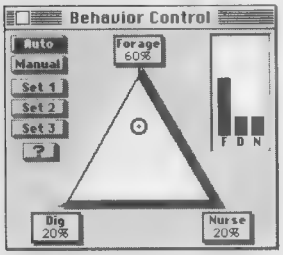
Males, like new queens, are big and expensive, and shouldn't be made in a Full Game until your colony can afford it. Males are useless in a Quick Game.

BROOD

Brood is a term that covers all the immature ants: eggs, larvae and pupae. The brood are cleaned and cared for by nurse worker ants.

Egg
Behavior
Hatching
Carrying
Nothing

ANT BEHAVIOR



Your ants have three basic behaviors: foraging, nursing and digging. You direct your workforce into these behaviors using the Behavior Control Window.

In addition to the basic behaviors, your ants can be recruited, and they can be alarmed.

FORAGING

Foraging is finding food *and* bringing it home safely. Returning home safely is a big part of it. Foragers generally have shorter life expectancies than ants with other jobs. They are often killed and eaten by spiders, ant lions, birds and other predators, as well as killed and eaten by ants from other colonies.

Since foraging is your food and energy source, you should allocate more workers to foraging than the other behaviors.

NURSING

Nursing consists of the care and feeding of the queen and the brood. The brood need to be carried out of the queen's chamber and cleaned. The larvae need to be fed.

> ***AntFact: Eggs, larvae and pupae need to be kept within certain temperature and humidity ranges, and nurse ants carry them from chamber to chamber all day long to meet their needs.***

In SimAnt, the nurses are shown on-screen carrying the brood around, as they do in real ant colonies. If you don't assign enough of your workforce to nursing, your eggs will not hatch, your larvae and pupae will not mature and your population will not grow.

DIGGING

Digging is the enlarging and maintaining of the nest. Your nest must be big enough to hold all your ants in case of an emergency (flood or lawn mower) where you all have to move or hide. It also has to have room for

food storage and for many brood chambers. The brood chambers need to be at various depths, which keeps them at different temperatures.

You shouldn't take too much away from foragers to dig, but don't neglect digging, at least until you have a sizeable underground nest.

RECRUITED ANTS

When ants are recruited, they rush to the Yellow Ant, and follow it around in an agitated state. They will attack and try to kill any enemies near them.

Ants stay recruited until the Yellow Ant dies or intentionally releases them.

ALARMED ANTS

Ants become alarmed when they come into contact with the alarm scent that the Yellow Ant can produce and spread on the ground. When ants come into contact with the alarm scent, they stay near the scent in an agitated state until the scent fades away.

The main use of the alarm scent in SimAnt is to "post guards" near food or colony entrances.

FOOD AND ENERGY

As living creatures, we need food. It is important, while playing SimAnt, to know what you and your ants can eat.

Food is the source of energy—the ultimate resource of living things. Much of playing SimAnt is energy management: use the food (energy) as efficiently as possible to obtain more energy (food). You invest the energy in different types of ants that can help you get more energy, until you can afford to reproduce and found new colonies in areas where you can find even more food.

STUFF YOU FIND

During the game, food will "appear" in various places in the yard. This might seem strange, but not from the ants' point of view. Since they don't go shopping or call the local store for delivery, all food they find, from

The biggest ant in the world is the elephANT.

dead insects to dropped ice cream cones, must seem to appear from nowhere.

Food does not automatically appear in an Experimental Game—you are the sole source of food during experiments.

For ease of recognition and because of computer limitations, all food will appear as green balls (in black and white versions it won't be green, but it will be balls). In the backyard, these food balls represent a lot of different things an ant might eat, including: dead insects or other animals, sap from plants, and food dropped by humans or pets. In the house these food balls primarily represent food to be stolen from humans.

As the Game Player, you can look around the Edit and Map Windows and find food. As the Yellow Ant, you can get the food, and take it back to the nest. Whenever you (or any other ant) come home with food, you automatically leave a chemical trail that other ants will follow to the food.

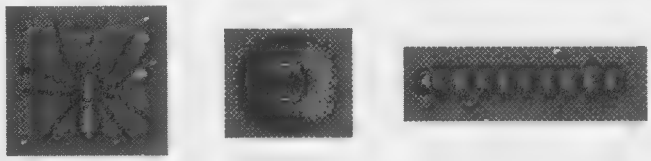
The other ants in your colony will also find food, but since they don't have computers to help them, they just wander around until they find it.

STUFF YOU STEAL

You can steal food from the red ants' nest. If you dare, you can sneak into the red ants' nest and take their food, but it won't be easy.

STUFF YOU KILL

After you kill spiders and caterpillars they turn into green balls of food. When you can kill ant lions, your ants eat them immediately; they don't become green balls.



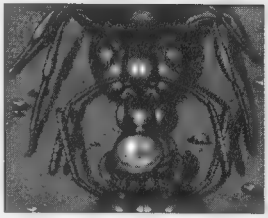
An obvious ant is flagrANT.

STUFF YOU GET FROM OTHER ANTS

Ants share food with each other. When a foraging ant brings in a load of food, it will put it in storage or give it to any member of the colony that needs it. Ants will even share food after they've eaten it.

Ants have two stomachs: a group stomach, called the *crop**, and their personal stomach. When ants eat, the food goes into their crop. When they need some food for themselves, it is released from the crop into their personal stomach and digested.

When an ant with a full crop meets a hungry nestmate, it will throw up some food for the other ant to eat. The polite and scientific reference for ants feeding other ants by puking in their faces is *trophallaxis**.



AntFact: Ants don't actually eat, they drink. They chew up their food, squeeze out and swallow the juice, and spit out whatever's left.
(This is sometimes known as the drinking ant's diet.)

When your Yellow Ant gets hungry, and isn't near food, a nearby black ant will feed it. If there are no black ants near, and you are very hungry, recruit an ant and it will feed you.

SCENTS AND CHEMICAL COMMUNICATION

Ants communicate with chemicals. Various glands in their bodies release very small amounts of chemicals into the air or onto the ground. Ants "smell" these chemicals with their antennae.

The messages they send aren't very complex, like, "Remember me? We met at the caste party last Thursday night, and I was wondering if maybe...."

They only communicate simple things like: "This way to food," "This way home," "I'm a friend," "I'm an enemy," and "PANIC!"

AntFact: By "smelling," ants can tell if other ants are from their own colony, and what caste they are, but cannot recognize or distinguish individual ants. In the ant world, the individual doesn't matter; only the ant's job in the colony, which is determined by its caste, matters.

In SimAnt, there are three types of communication scents: nest markers, trail markers, and alarm.

NEST MARKERS

Nest Markers are the scent of the ant colonies. Ants can recognize this scent, and follow it home. They can also recognize the scent of another colony, and know that danger is near.

The display of nest markers for both nests can be turned on and off in both the Edit and Map Windows.

TRAIL MARKERS

Trail Markers are left by ants as they return home with food. Other ants smell the trail and follow it. Trail markers are not directional—ants can't tell which way is home and which way is food. They just pick a direction and go if they wind up back at home, they turn around. Trail markers fade away from trails that are no longer used, and can be washed away by rain.

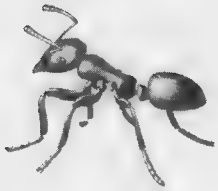
The display of trail markers for both nests can be turned on and off in both the Edit and Map Windows.

ALARM SCENTS

Alarm Scents in SimAnt put ants into "defend mode." When ants smell the alarm scent, they will mill around the scented area, and defend it from anything that comes near. Alarmed ants stay alarmed until the scent fades away or is washed away by rain.

The Yellow Ant can produce this scent, and uses it to make ants guard the nest or food from red ants or predators.

Ants that smell good are fragrANT.



You can test the effect of nest and trail markers and the alarm scent on ants in experimental mode.

RECRUITMENT

AntFact: Ants "recruit" other ants in a number of ways, but primarily chemically. When one ant finds a lot of food or senses a danger, it will recruit other ants to follow and help.

Recruitment in SimAnt is not very realistic. The recruitment process in real ants is a fairly complex process. For the purposes of the game, we've simplified it a great deal.

In SimAnt, only the Yellow Ant can recruit (through a menu or keyboard key). The recruited ants follow the Yellow Ant wherever it goes, and attack any enemies that come near.

A useful tactic is to recruit lots of ants, take them near some food, then release them. They'll all pick up some food and take it back to the nest.

ENEMIES AND DANGER

There are a number of enemies and dangers that ants face in their daily lives. Believe it or not, ants aren't exactly the most-loved critters in the universe. In SimAnt, the enemies you will face are: the red ants, spiders, ant lions, and humans.

THE RED ANTS

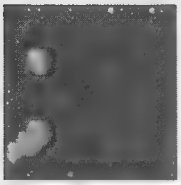
The red ants are your main competition. They eat the same food as you do, and want to dominate the same territory. When they outnumber the black ants by a safe margin, they will launch an all-out attack.

THE RED TERMINATOR

The Red Terminator is an initiator ant. The red colony's equivalent of the Yellow Ant, it wanders around the outskirts of red territory and keeps an eye out for food and enemies. When the Red Terminator senses food, it recruits help to gather it. When it senses black ants approaching, it recruits red ants and meets them in battle as far from the red nest as possible.

There is always one Red Terminator. If it dies, another red ant is picked at random to take its place.

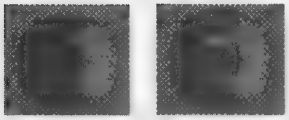
SPIDERS



The spider wanders around eating ants. While it eats a lot, it is only dangerous to colony survival in the early stages of the game when you have very few ants. The spider can be a real nuisance when it eats the Yellow Ant. It can be a real help if it eats a lot of red ants.

The spider never goes underground. The spider can be killed, but it's difficult. Once it dies, it becomes food for the ant colony.

ANT LIONS



Ant lions are real. (I didn't believe it at first, either.) They aren't ants and they aren't lions: they're larvae of an insect similar to a dragon fly, and are called doodlebugs in some parts of the United States.

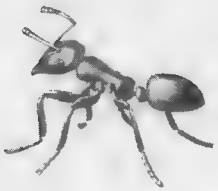
> ***AntFact: Ant Lions are about a half-inch long, and live at the bottom of cone-shaped pits with only their mouths showing above ground. The pits are made of loose dirt, and ants or other insects passing by slip down the sides into the waiting jaws of the ant lion. Sometimes, if it looks like the prey might get away, the ant lion will flick pieces of dirt at it to knock it down.***

In SimAnt, ant lions never move around or come out of their holes. They can be killed and eaten, but they don't turn into green balls of food.

HUMANS

Face it, humans are as much of an annoyance to ants as ants are to humans. In the yard, humans cause problems for ants with their feet and with the lawn mower.

When a foot appears, it means death to any ants caught under it, in two seconds flat (very flat). There is no defense against the dreaded foot, and



very little warning. Depending on the sound capabilities of your computer, you might be able to hear the footsteps coming from an adjacent Patch. If you do hear them, you might want to get quickly underground. Or, if you have a lot of recruited ants, release them to disperse so the foot won't get as many.

When the lawn mower passes over, it sucks up any ants on the surface and blows them away across the yard, never to be heard from again. There is no defense against the lawn mower, only retreat. When you hear it, get underground. Setting the behavior control so all the ants are digging or nursing will send them scurrying underground.

In the house, humans cause even more problems. In addition to feet, they have insecticide.

INSECTICIDE

You will only have to worry about insecticide spray in the house. When humans spray, most of the ants in that Patch that are above ground will die. Depending on your computer, you may be able to hear the spray and rush as many of your ants underground as possible.

RAIN

When it rains, the lower portions of your nest will flood. You must bring your ants and brood up to dry land or they will drown.

Rain washes away alarm and trail scents.

BATTLES

When real ants from different colonies meet, they may or may not fight, depending on the species, territory size, and food supply. In SimAnt, the red and black ants are in direct competition for the same food on the same small patch of ground. When red and black ants meet, they fight.

Soldier ants are militANT.

Battles between ants are pretty much one-on-one. The winner of the battle is determined by the two ants' size (caste), health, and a random factor. The chart below shows the odds in battles between ants.

	Worker	**Soldier**	**Queen**	**Breeder**
Worker	50/50	20/80	30/70	70/30
Soldier	80/20	50/50	60/40	90/10
Queen	70/30	40/60	50/50	80/20
Breeder	30/70	10/90	20/80	50/50

The above odds are modified by the health of the two combatants. If one ant has a higher health rating than the other (see the Health Graphs in the Edit Window Control Panel) its odds are increased by 10% and the other ant's odds are lowered by 10%.

MATING FLIGHTS

Full Games involve spreading your ants all over the house and yard by founding new colonies. New colonies are founded by producing breeders, having mating flights, and placing the new queen into new Patches in the house and yard. In Quick Games there is no point in producing breeders or having mating flights.

A mating flight is demonstrated in the Tutorial section, and a complete explanation of the process is found in the section on the Map Window below.

An ant that chews its cud is a ruminANT.

CONTROLLING SIMANT

IN GENERAL

SimAnt is fairly easy to play. Everything can be controlled with buttons, menus, and mouse-clicks, with a number of keyboard shortcuts.

MOUSE AND KEYBOARD

A mouse is highly recommended even for those computers that don't come with one. If your computer doesn't have one, you can play the game using only keyboard commands, but using a mouse is much easier. Much easier. Very much easier.

A complete list of all keyboard commands and shortcuts for your computer can be found in the machine-specific addendum.

This manual assumes that you know how to use the mouse to point at different places on the screen, and that you know how to click, double-click, and click and drag. If you don't know how to do these things, please take a look at the manual that came with your mouse or computer.

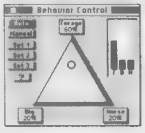
MENUS AND CONTROL PANELS

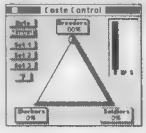
All versions of SimAnt have a Menu Bar at or near the top of the screen. The use of menus follows the standard conventions for your type of computer. In the case of DOS-based (IBM/Tandy and compatibles) computers where there is no set standard, a brief explanation of how to use menus will be found in the machine-specific Addendum/Quick Start Guide.

The control panels are groups of buttons that are activated by clicking the mouse on them. If you are playing without a mouse, an explanation of how to activate the control panels with your keyboard will be found in the machine-specific Addendum/Quick Start Guide.

SPECIAL CONTROL WINDOWS

There are two special windows you will use for controlling your ants: the Behavior Control Window sets your ants' basic behavior patterns; and the Caste Control Window sets the different types of ants that will be born in your colony. A complete explanation of these windows is found below in the Windows section.





SIMANT

THE YELLOW ANT PART 2

The Yellow Ant is your "insect alter ego"—your main method of controlling, teaching and interacting with your ants is through the Yellow Ant.

The Yellow Ant is the initiator ant for the black colony, and is only controlled by you.

The Yellow Ant can be any live, mature black ant in your colony: no dead ants, eggs, larvae or pupae. You cannot make a red ant into the Yellow Ant.

THINGS TO DO WITH THE YELLOW ANT

Lead your ants to food.
Lead your ants to battle.
Lead your ants to safety underground when feet or lawn mowers approach.
Dig nest chambers.
Eat.
Transfer to the queen and move her deep into the nest for safety.
Pick up and move rocks to build barriers or block nest entrances.
Drop the alarm scent near food or nests that need guarding.
Fight red ants with your bare mandibles.

DOING THINGS WITH THE YELLOW ANT

You can control the Yellow Ant from either the Edit or the Map Window. In the Edit Window, just click. In the Map Window, you must hold down the Shift key when you click.

BECOMING THE CENTER OF ATTENTION

To center the Yellow Ant in the Edit Window, just click on it briefly.

MOVING

To move the Yellow Ant while in the Edit Window, click where you want it to go. It will try to take the straightest path to its goal. To move it while in the Map Window: hold down the Shift key and click where you want it to go.

An ant with a split personality is sibliANT.

Be careful when moving the Yellow Ant long distances: it could be caught by the spider or an ant lion, or may be killed by red ants.

Sometimes, when you try to move the Yellow Ant while underground, it cannot find its way. At these times you will have to make it dig.

DIGGING

While underground, the yelow ant can dig. In the Edit Window, just double-click where you want it to dig to. To dig in the Map Window, hold down the Shift key and double-click.

PICKING UP AND PUTTING DOWN

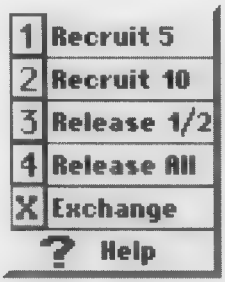
The Yellow Ant can pick up and put down food, eggs, larvae, pupae and small rocks.

To make it pick up while in the Edit Window, double-click on the object. To make it put down, double-click where you want it to drop its load. When in the Map Window, hold down the Shift key while double-clicking.

RECRUITING/RELEASING

The Yellow Ant is an initiator. It can recruit other ants to follow it to food or danger.

To recruit in the Edit Window, click and hold on the Yellow Ant to open the Yellow Ant Control Menu. Slide the pointer to highlight either "Recruit 5" or "Recruit 10" and release the pointer. Five or 10 ants will immediately rush to the Yellow Ant and mill about, ready for action.



To release the ants, click and hold on the Yellow Ant to open the Yellow Ant Control Menu, and slide the pointer to highlight either "Release 1/2" or "Release all" and release the pointer. Once released, the ants will go on their merry way.

To recruit or release in the Map Window, hold down the Shift key and follow the instructions for releasing in the Edit Window.

EXCHANGING

The Yellow Ant can exchange places with any live, adult black ant.

In the Edit Window, click and hold on the Yellow Ant to open the Yellow Ant Control Menu, slide the pointer to highlight "Exchange" and release the pointer. Then click on the ant that you want to exchange with. The Yellow Ant becomes the caste of the exchanged ant (worker, soldier, queen, etc.).

To Exchange in the Map Window, hold down the Shift key and follow the instructions for the Edit Window.

SETTING THE ALARM

The Yellow Ant can leave a trail of alarm scent that, when sensed by black ants, causes them to stay near the scent and mill around, ready for battle. Use this to post guards near food or colony entrances.

Pressing the Zero key **[0]** on the keyboard toggles you into Alarm Mode. This does two things: turns on the display of the alarm scent, and drops the alarm scent behind the Yellow Ant as you move it.

Press the Zero key again to toggle out of Alarm Mode.

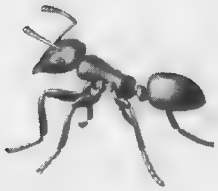
Repeatedly dropping scent in any one place increases the intensity of the scent and increases the black ants' reaction to it. The more scent you drop in one place, the slower it fades.

The alarm scent is washed away by rain.

GETTING HELP

At any time you need help with the Yellow Ant, click and hold on it to open the Yellow Ant Control Menu, slide the pointer to highlight the question mark, and release the pointer. A dialog box appears, and explains how to control Ol' Yeller.

Some soldier ants are sergeANTs.



FIGHTING

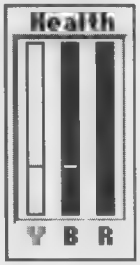
If you come in close contact with a red ant, it will usually attack. See the chart above for battle odds with different types of ants. If you want to pick a fight with a particular red ant, double-click on it.

FOOD, HEALTH, ENERGY

The Yellow Ant needs food to survive, and the more it moves, digs, or carries things, the more energy it burns. The hungrier it is, the lower its health rating. The lower its health rating, the easier it is for a red ant to beat it in a fight.

When the Yellow Ant is hungry and picks up food, it will eat it right then and there, increasing its health level. When it is hungry and not near food, nearby black ants will feed it. If it is starving, and there are no black ants near, recruit some and they will feed it.

You can also double-click on any black ant to force it to feed you. Unless it is starving, it will share whatever it has in its stomach with you.



The Yellow Ant's health is shown in the Edit Window, at the bottom of the control panel. The higher the yellow bar, the healthier the Yellow Ant.

Somewhere in that bar is a horizontal line. This line is the warning level that acts like the warning light on your gas tank. You can set this warning level by dragging it up or down.

When the Yellow Ant's health gets below the line, another ant will come and feed it. The higher you set the line, the more often you will be fed, and the more often you will have to stop and eat.

The disadvantage of a high warning level is that you will have to stop constantly for meals. The advantage is you maintain a high health level, so you will have better odds in fights with red ants.

Next to the yellow bar is a black bar that shows the overall health of the black colony. It also has a warning level you can set. When the level gets below the warning line, you will receive messages telling you to find food.

DEATH AND REBIRTH

As long as there is a black colony, there will be a Yellow Ant. If it dies (and it will, often), it will hatch from the next egg laid by the black queen and be reborn.

When the Yellow Ant dies, all recruited ants are released.

There is no big penalty for the Yellow Ant dying in SimAnt. With ants, it is the colony that is important, the colony that must survive; the individual ant is expendable. The only penalty for the Yellow Ant dying is lost time and energy.

Worker ants are vigilANT.

MENUS

Here is a listing and explanation of all menu items in SimAnt. If there are any additions, omissions or differences, they will be explained in the addendum for your computer.

FILE MENU OR PROJECT MENU

This menu has the commands for file management and quitting SimAnt.

ABOUT SIMANT...

About SimAnt... brings up vital and fascinating facts about this game. If your computer has a special menu, like the Macintosh "Apple" menu, this item will be there, and not in the File Menu.

NEW

New opens the New Game Window allowing you to start a new Quick Game, Full Game or Experimental Game.

OPEN OR LOAD

Open lets you load and play a pre-saved game.

SAVE

Save is for saving the current game to disk. If the game has not been saved before, you will be prompted for a file name.

SAVE AS...

Save As... is for saving the current game to disk. You will always be prompted for a file name.

QUIT

Quit ends SimAnt.

WINDOW MENU

This menu is for opening and activating the various windows in SimAnt.

EDIT

Edit opens or activates the Edit Window.

MAP

Map opens or activates the MapWindow.

BEHAVIOR

Behavior opens or activates the Behavior Control Window.

CASTE

Caste opens or activates the Caste Control Window.

HISTORY

History opens or activates the History Graph Window.

INFO

Info opens or activates the Information Window, which gives a tutorial on real ants.

STATUS

Status opens or activates the Status Window, which gives you a feedback on your performance as an ant, and an overall score in Quick and Full Games.

VIEW MENU

The View Menu lets you select different views for the Edit and Map Windows.

YARD

Yard displays the Surface View in the Edit Window and the Yard View in the Map Window.

HOUSE

House displays the Surface View in the Edit Window, and the Yard View with the interior of the house visible in the Map Window.

STRATEGIC

Strategic displays the Surface View in the Edit Window, and the Strategic View in the Map Window.

GRAPHIC

Graphic displays the Surface View in the Edit Window, and the Graphic View in the Map Window.

SURFACE

Surface displays the Surface View in the Edit Window and the Patch View in the Map Window.

BLACK NEST

Black Nest displays the underground view of the black colony's nest in both the Edit and Map Windows.

RED NEST

Red Nest displays the underground view of the red colony's nest in both the Edit and Map Windows.

OPTIONS MENU

The Options Menu lets you set a number of game-play options to suit your taste. Options are active if they have a checkmark to their left.

AUTO TRACK

Auto Track scrolls the area in Edit Window to keep the Yellow Ant at the center of the window.

MUSIC

Music toggles the playing of music on and off. The amount and quality of music available to you depends on your computer.

SOUND EFFECTS

Sound Effects toggles the sound effects on and off. The amount and quality of sound effects available to you depends on your computer. Some of these sounds are really disgusting, so you may want to turn them off sometimes. Then again, some of them are warnings of approaching danger. It's your choice.

EVENTS

Events toggles on and off the display of various event descriptions during the game that appear in small pop-up boxes.

Helpful workers are assistANTs.

MESSAGES

Messages toggles on and off the display of helpful hints and messages during the game. These will appear in the Message Bars in both the Edit and Map Windows

SILLY

Silly toggles on and off the display of wise remarks made by the ants and their friends.

SPEED MENU

The Speed Menu lets you set the rate at which time passes in SimAnt.

PAUSE

Pause stops the simulation, and puts it into "single-step" mode. You can move the Yellow Ant while the game is paused, but the simulation will run while the Yellow Ant moves.

You must select Pause again (or UnPause) to return to normal time. Selecting one of the other speeds will not turn off the pause.

SLOW

Slow sets the simulation to its slowest continuous speed.

NORMAL

Normal sets the simulation speed to move the ants at a realistic-looking speed.

FAST

Fast sets the simulation speed to the fastest speed possible on your computer while maintaining smooth animation.

ULTRA

Ultra lets the simulation run even faster by updating the graphics less often. The animation will look choppy, but time will pass very quickly.

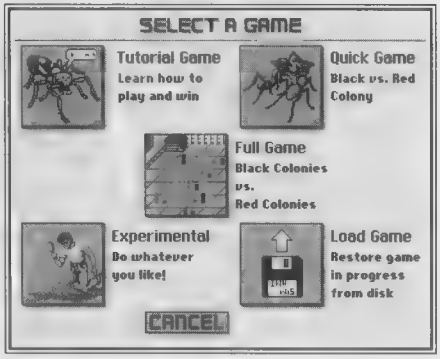
Individually, ants are stupid.
Together, they're brilliANT.

WINDOWS

One of the main differences between SimAnt on different computers is the way the Title Bars and Scroll Bars look (and sometimes act) on windows. Be sure to check the machine-specific Addendum/Quick Start Guide for your computer for details.

SELECT A GAME WINDOW

This window appears whenever you first start SimAnt and when you select New from the File (or Project) menu. It allows you to choose the type of game you want to play—Quick, Full, or Experimental—by clicking on the button of your choice. You can also start the on-screen Tutorial or load a previously saved game.



QUICK GAME

A Quick Game is played in only one Patch of the backyard. The object of a Quick Game is to destroy the red ant colony and take over the section of the backyard.

FULL GAME

A Full Game is played all over the whole yard and in the house. The object of a Full Game is to dominate the entire yard and house, destroy the red ants, and drive out the pesky humans.

EXPERIMENTAL

An Experimental Game gives you various tools and toys, and sets you free on the ants. Run them through mazes, test their reaction to various chemicals, even spray them with insecticide.

OPEN OR LOAD

Load an existing game from a disk.

TUTORIAL

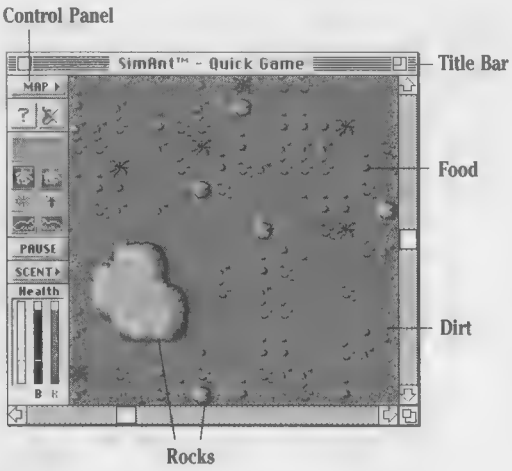
Tutorial begins the on-screen Tutorial.

CANCEL

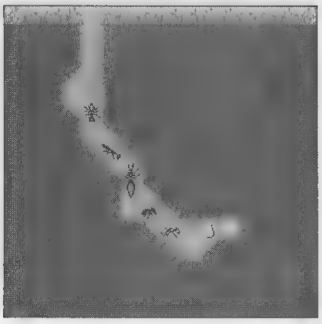
If you change your mind and decide not to start a new game, you can cancel and go back to the old game.

IN GENERAL

The Edit Window is your close-up view of the ants' world. It is where you can see the details of ant life and their interaction with other ants, insects and spiders. It is where you will use the Yellow Ant the most.



The Edit Window only shows part of the Patch at a time, whether it is in the house or in the yard. Use the scroll bars, arrows and boxes to see different parts of the Patch.



In this window you can see your ants both above and below ground, inside the house or out.

The Edit and Map Window are linked together—when you change the view from above to below ground in one window, the view will also change in the other.

THINGS IN THE EDIT WINDOW

Most of the things you'll see in the Edit Window are easily recognizable. There are bits of plants, dirt, rocks, kitchen sinks, stoves, carpets, and other common items. There are red ants, black ants, and dead ants. There are spiders, caterpillars and sow bugs (also known as roly-poly or soccer-ball bugs).

Below is a list of the less common things seen in this window, and an explanation of how some of the more common ones behave in SimAnt.

The **Yellow Ant** is your insect alter ego. You will use this ant to lead the other ants in your colony to food or battle.

Ants can be black or red. The black ants are the good guys (your colony), and the red ants are the bad guys. We made the red ants the bad guys because a number of us were bit by red ants and it hurt.

Ants can be workers, soldiers, queens, males and new queens. Ants usually stay busy, and can be recruited and led by the Yellow Ant. Ants can also be dead. Dead ants aren't any fun. They just lie there. At least they don't bite.

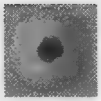
To get information about individual ants, click and hold on them to open a little info window. This window tells the type of ant, what it is doing at the time, and what, if anything, it is carrying.

Queen	Worker	Soldier	New Queen
Behavior Egg Laying	**Behavior** Foraging	**Behavior** Resting	**Behavior** Pre-Flight
Carrying Nothing	**Carrying** Nothing	**Carrying** Nothing	**Carrying** Nothing

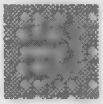
Brood are the immature ants, eggs, larvae and pupae. To get information about individual eggs, larvae or pupae, click and hold on them to open a little info window. This window tells the type of ant; what it is doing at the time; what, if anything, it is carrying; and its health.

Egg	Larva	Pupa
Behavior Hatching	**Behavior** Hatching	**Behavior** Hatching
Carrying Nothing	**Carrying** Nothing	**Carrying** Nothing

Soldier ants are combatANTs.



Anthills are entrances to the nests. There can be one or many anthills for each nest.



Food is shown as green balls. These balls represent anything ants might eat, from dropped candy to dead insects.

Sow Bugs wander around and do nothing but get in the way. They don't eat ants, and ants don't eat them. These bugs are also called roly-polys because they roll up into a ball when you touch them.

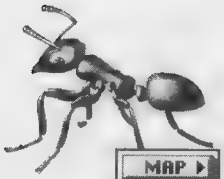
Caterpillars wander around the yard just asking to be eaten. They are a delicious and nutritious source of food for ants. When enough ants surround a caterpillar, they kill it and it turns into green balls of food. There is only one caterpillar at a time in SimAnt.

Spiders roam the exterior of the house and eat ants. These spiders are hungry, and eat red and black ants indiscriminately. Spiders can also eat the Yellow Ant (you). There is only one spider at a time in SimAnt. Spiders can be killed and eaten, but not easily.

Ant Lions aren't lions (or ants). They are the larvae of an insect like a dragonfly. They bury themselves in the ground at the bottom of a small pit with just their mouths exposed. When an unsuspecting ant slips down the pit, it is chomped up and swallowed. Ant lions can eat the Yellow Ant, so be careful. Ant lions can be killed and eaten.

Human Feet are a constant source of annoyance to ants. They appear out of nowhere and squash ants, left and right. Depending on your computer's sound capabilities, you may be able to hear footsteps approaching and hide underground until they go away.

Head soldiers are commandANTs.



Lawn Mowers are deadly menaces. When one passes over ants, it sucks them up and blows them to oblivion. Depending on your computer's sound capabilities, you may be able to hear the lawn mower approaching and hide underground until it goes away.

Rocks are barriers to ants. They have to go around them. Ants can also pick up and carry small rocks.

THE EDIT WINDOW CONTROL PANEL

The Edit Window Control Panel provides tools to navigate around the Patch, change views above and below ground, see the ant trail and nest markers, check on the health of the red, black and yellow ants, and access the experimental tools.

The **Map Button** is a very useful item. Click on it to see a miniature view of the whole map. In this little map is the Edit Rectangle, which shows the area presently visible in the Edit Window. Click anywhere in the map to move the rectangle and redraw the Edit Window in that location. This is a quick way to navigate around the Patch.

The small map will be above or below ground, depending on the current view in the Edit Window.

The Map Button will also open or activate the Map Window if you click and hold on it, then slide the pointer into the little map and release the pointer.

Help displays on-screen explanations of all buttons in the Edit Window Control Panel.

Experiment, while in a Quick Game, lets you switch to an Experimental Game. You cannot switch to an Experimental Game from a Full Game.

While in an Experimental Game, the Experiment button displays the active experimental tool. Click and hold on this button to see a submenu that lets you choose the different experimental tools or switch to a Quick Game. A complete description of the experimental tools is in the next section below.

Surface changes the view in the Edit Window to the surface of the Patch.

Black Nest changes the view in the Edit Window to the underground nest of the black ants.

Red Nest changes the view in the Edit Window to the underground nest of the red ants.

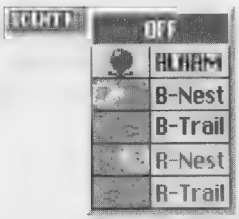
Yellow Ant centers the Edit Window around the Yellow Ant, wherever it is.

Spider centers the Edit Window around the spider.

Black Queen centers the Edit Window around the black queen.

Red Queen centers the Edit Window around the red queen.

Pause puts the game into a single-step mode. You can move the Yellow Ant while the game is paused, but while it actually moves, so will everything else.



Scent brings up a submenu that allows you to view the location of the red and black colony, trail-marking and alarm scents.

Health Graph shows the relative health of the Yellow Ant and the red and black colonies. The higher the bars, the better the health.

In the bars for the Yellow Ant and the black colony are horizontal lines. You can drag these lines up and down to set warning levels.

When the Yellow Ant's health gets below the line, another ant will come and feed it. The higher you set the line, the more often you will be fed, the more often you will have to stop and eat, and the healthier you will be.

When the black colony health level goes below the warning line, you will receive messages and advice telling you to find food.

THE EXPERIMENTAL TOOLS

The experimental tools are only available during an Experimental Game.

Info lets you find out about individual ants. Click and hold on them to open an info window that tells the type of ant, what it is doing at the time, and what, if anything, it is carrying.

Barriers brings up a submenu that lets you choose between walls and rocks to use as barriers. Barriers are for making mazes and obstacles to test ant intelligence and foraging efficiency. To remove barriers, hold down the Option or Alt key on the keyboard and click on the barrier.

Dig/Fill brings up a submenu that lets you choose between digging and filling. Above ground, digging will create a shallow anthill. Below ground, you can dig tunnels and chambers. Fill lets you fill in tunnels and chambers underground.

Use these tools to make underground mazes, block ants from the surface, isolate the queen, and other torturous activities.

Add Ants brings up a submenu that lets you add black or red ants. Mix and match these enemies in different situations to see what happens.

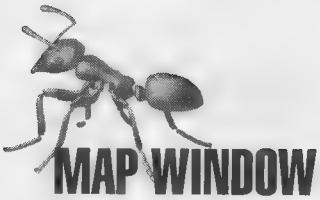
Add Food brings up a submenu that lets you add one or 20 pieces of food at a time. Use the food as bait in mazes.

Food will not automatically appear in Experimental Games. If you don't add any yourself, all the ants will die.

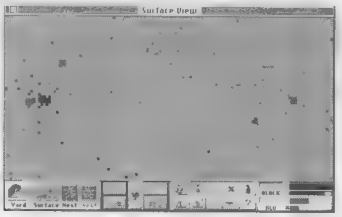
Drop Trails lets you experiment with the chemicals that ants use to mark their homes and trails to food. You can also put down the scent that puts ants into alarm mode.

Insecticide lets you apply poison on or near ants and other insects to see what happens...as if you didn't already know.

Queens are always expectANT.



The Map Window gives you a number of overall views of the ant "world." The Map Window is closely tied to the Edit Window: when you change the Map view, the Edit view will change to show the same area or level.



VIEWING LEVELS

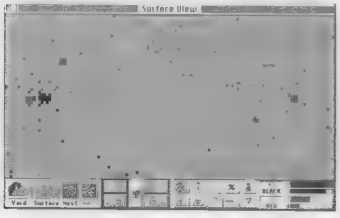
There are two different viewing levels in this window: Patch Level shows the patch of ground (or section of the house) that is active; Yard Level shows the whole yard and house.

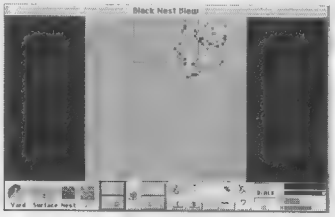
Patch level is for playing Quick Games and for individual battles within Full Games. Yard Level is for making strategic moves to different Patches, mating and spreading colonies.

The Map Window Control Panel changes for each of these levels, giving you access to the tools and information needed at the time.

PATCH LEVEL

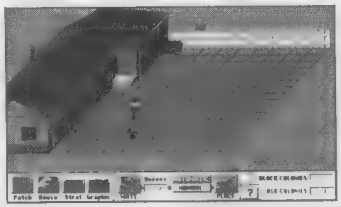
At Patch Level you see the active Patch, whether it is inside or outside the house. You can view either the surface of the Patch or the underground nests for each colony that exists in that Patch.

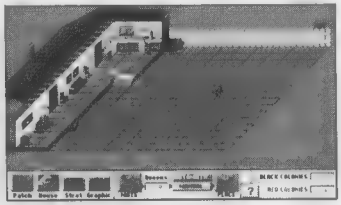




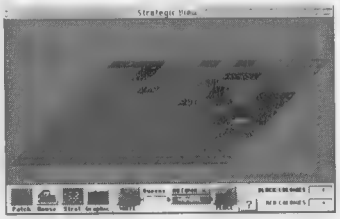
YARD LEVEL

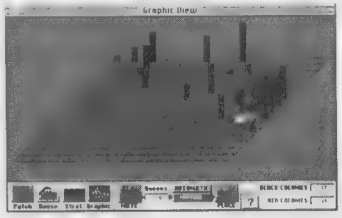
At Yard Level you see the entire game universe: the whole yard and the house. You can toggle on and off the display of the interior of the house.





There are also two other views at this level that are useful in Full Games. The Strategic View shows which of the patches are ruled by each (red or black) colony. The Graphic View shows the relative populations of red and black ants in each patch with bar charts.





THE MAP WINDOW AT PATCH LEVEL

The Map Window at Patch Level displays the Patch of the yard, inside the house or out, that is presently active.

THINGS IN THE MAP

Edit Rectangle — Somewhere in the map area of the Map Window is the Edit Rectangle. This shows the area of the map that is visible in the Edit Window. Click and drag it to change the Edit Window display. Double-click in this rectangle to open or activate the Edit Window.

Other Things — At this range, most things, including ants, are little more than dots. Discerning different types of ants in this window is much easier if you have a color monitor. Below is a chart of the color-coded objects that appear in the Map for computers with color monitors. The colors used on different computers may vary. Check your machine-

Anteaters are digestANTs.

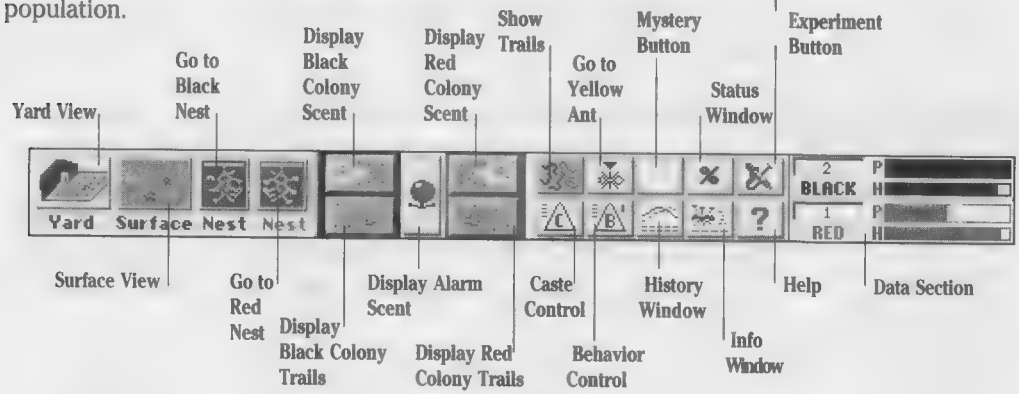
specific Addendum/Quick Start Guide. If you have a black and white monitor, check your machine-specific Addendum/Quick Start Guide for a chart of black and white Map Window objects.

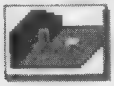
Item	Color
Dirt	Light Brown
Rocks	Light Grey
Yellow Ant	Yellow square
Black Ant, no load	Black square
Black Ant, carrying food	Light Green square
Red, no load	Red square
Red, carrying food	Orange square
Dead Ant	Dark Brown square
Food	Dark Green square
Sow Bug	Light Blue square
Rain	Blue squares
Caterpillar	Green line w/brown head
Ant Lion	White square

You will also see Feet, Lawn Mower, Spiders and Colony Entrances (Anthills) in the Map Window.

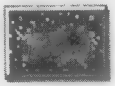
THE MAP WINDOW CONTROL PANEL AT PATCH LEVEL

The Map Window Control Panel is a series of buttons and graphs that change the views in the window, access other windows, access experimental tools, and give information on red and black ant health and population.





Yard changes the Map Window to Yard View. The next section of the manual covers the Map Window at Yard View.

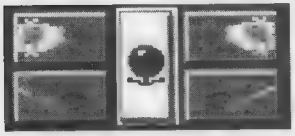


Surface displays the surface of the Patch.

Black Nest displays the black colony's underground nest.

Red Nest displays the red colony's underground nest.

Nest Markers display the pheromones that mark the red and black nests.



Trail Markers display the pheromones that mark the trails to and from food left by the red and black ants.

Alarm Signal displays (if there are any present) the pheromones that put ants into alarm mode, which causes them to emit more pheromone that puts them into alarm mode, which....

Trails causes ants to leave trails behind them so you can see the patterns ants follow as they forage for food. This in no way affects the game: these are not pheromone trails.

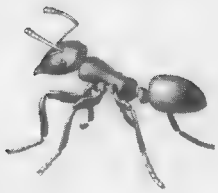
Yellow Ant centers the Edit Rectangle on the Yellow Ant.

Mystery Button does different things, or not, as the case may be, or not.

Status displays the Status Window, which gives you feedback on your performance as an ant.

Experiment, while in a Quick Game, lets you switch to an Experimental Game. You cannot switch to an Experimental Game from a Full Game.

While in an Experimental Game, this button displays the active experimental tool. Click and hold on this button to see a submenu that lets you choose the different experimental tools or switch to a Quick Game.



All of these tools can be used while in the Map or Edit Window. While in the Map Window, hold down the Shift key to activate them. A complete explanation of each experimental tool is found in the section describing the Edit Window.

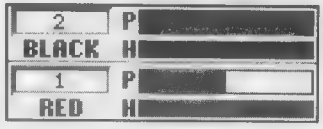
Behavior Control opens or activates the Behavior Control Window.

Caste Control opens or activates the Caste Control Window.

History opens or activates the History Graph Window.

Info opens or activates the Info Window.

Help displays on-screen help for the Map Window Control Panel.



Data Section displays the black and red ant populations and bar graphs that show the relative populations and health of the two colonies.

Click and hold in this section to see a population report of the different castes of ants in both colonies.

THE YELLOW ANT AT PATCH LEVEL

You can control the Yellow Ant in the Map Window in Patch Level the same way as you do in the Edit Window, except you must hold down the Shift key and click. Be careful when moving the Yellow Ant long distances in this window. It is easy to step in an ant lion trap by accident.

THE MAP WINDOW AT YARD LEVEL

The Map Window at Yard Level displays the whole yard and house—the entire SimAnt universe. There are three different views at this level: the House View, the Strategic View and the Graphic View. In all views the yard is divided up into 192 squares, each of which is a Patch where a battle can take place.

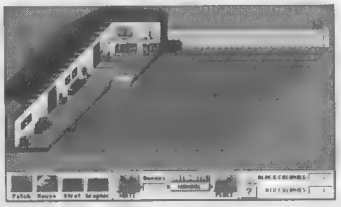
The active Patch flashes, so you know where you came from. During a Full Game, you can transfer from Patch to Patch in any of the Yard Level

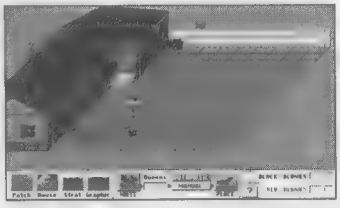
An ant that comes from another colony is an immigrANT.

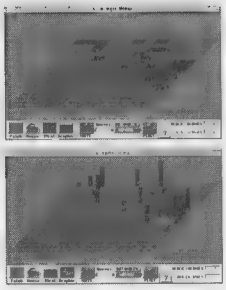
views by double-clicking in the Patch you want to go to. You can only go to Patches where there is a black colony or a newly placed new queen.

You can also initiate mating flights from each of these views, and place your new queens in different Patches.

The House View shows the house (interior and exterior) and yard, with a dog and human doing their dog and human act. The cat generally does its best to annoy the dog, as any respectable cat should. When the human steps on a part of a patch where there are ants, the ants are flattened. When the human mows the lawn and the mower passes over ants, they are blown away into oblivion. The dog doesn't affect the ants at all, but it can throw the cat for a loop now and then. The bird eats ants during the mating flights.







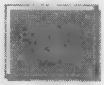
The Strategic View shows which of the Patches are dominated by which ant colony. Black-dominated squares are shown black. Red-dominated squares are red (or grey on black and white monitors). Neutral squares are shown green (or white on black and white monitors).

The Graphic View shows the relative black and red populations for each Patch.

Ants that keep books are accountANTs.

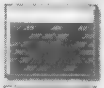
THE MAP WINDOW CONTROL PANEL AT YARD LEVEL

Patch zooms the Map Window in to Patch Level. The previous section of the manual covers the Map Window at Patch Level.

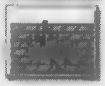


House sets the view to House View. If it is already in House View, it toggles the view between the interior and exterior of the house.

Strategic sets the view to the Strategic View.



Graphic sets the view to the Graphic View.



Mating Controls are for starting the mating cycle and founding new colonies in the yard. A complete description of mating and founding is in the next section below.

Help displays an on-screen explanation of all the buttons and features of the Map Window Control Panel.

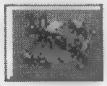
Colony Tally gives the total number of red and black colonies in the yard.

MATING AND FOUNDING NEW COLONIES

A major part of playing Full Games is garnering your energies, mating, and carefully placing new colonies.

Before you can mate, you must set the Caste Control Window to produce breeders (males and new queens) in at least one Patch.

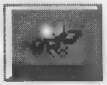
When you have a supply of breeders and are ready to mate, open the Map Window in one of the Yard Views (House or Strategic).



Click on the **Mate** button to begin the mating cycle. After a short while, the number of fertilized queens that can found new colonies appears to the right of the Mate button.

If you want the queens to fly off and pick their own new homes, click on the Automatic button.

If you want to place the new queens yourself, click on the manual button before you start the mating cycle.



When you have available queens, and want to place them, click on the Place button, then click on one of the Patches in the yard. A new colony will be founded there.

You can click the Place button, then click on one Patch, then click the Place button, then click on a Patch, and on and on until all your queens are placed, or you can click the Place button, then hold down the Shift key while clicking on multiple Patches.

You can only place queens a distance of three Patches from the Patch where they were born. You can't place a queen on a patch where there is already a black colony. If you have more queens than you can place, they will slowly be eaten by birds. Sometimes they come in handy: if a colony dies and you have a spare queen, you can place it and try again.

If you transfer to another Patch without placing all the queens, they will die, and won't be there if you come back.

Lots of ants do the same jobs. They're redundANT.

BEHAVIOR CONTROL WINDOW

The Behavior Control Window is where you control the basic behavior of your ants.

There are three main behaviors that ants can have in SimAnt: Forage, Dig, and Nurse. These behaviors are explained in detail above in the section Ant Modes of Behavior.

The ants are controlled by using a three-way "joystick." Each of the three behaviors is found at a corner of the triangle. In the middle of the triangle is the joystick that you can click and drag. If you drag it all the way into any one corner, all the ants will follow that behavior. If it is in the exact middle, your ants will be equally divided between the behaviors. If you are careful, you can set your ants' behavior in any ratio of the three behaviors.

At each corner of the triangle is a box displaying Forage, Dig or Nurse, and showing the percentage of ants active in each behavior. Click in any of these three boxes to toggle between displaying percentages and actual numbers of ants.

To the right of the triangle is a set of bar graphs that give you another view of how your labor is divided up between behavior modes.

These three basic behaviors are overridden if ants are recruited by the Yellow Ant, if they happen across some alarm scent, or if they meet an enemy and automatically enter attack mode. If ants are recruited, the remaining ants will redistribute themselves into the behavior ratios you set.

AUTO, MANUAL AND PRESETS

When the Auto button is depressed, the simulation automatically controls the behaviors of the ants. It will do a fairly good job, but will not respond well to emergencies. You may also need to take control for certain strategic moves.

When in Manual mode, the behavior ratios stay as they are until you change them.

There are three Presets you can use to save favorite settings for strategic moves or emergencies. To set the Presets, drag the joystick to the setting you want, then click on any of the Set buttons. To recall the setting at a later time, just click on the same Set button.

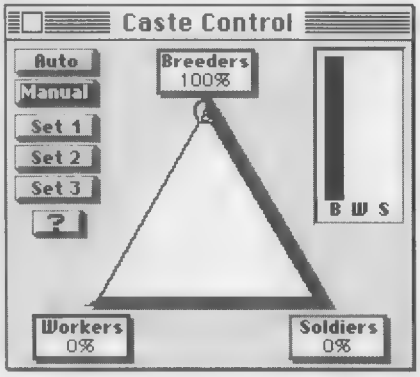
HELP

Click and hold on the Help button to see an on-screen explanation of all controls in this window.

Soldier ants that win battles are triumphANT.

CASTE CONTROL WINDOW

The Caste Control Window lets you control what types of ants are born in your colony. There are three main types, or castes, of ants in SimAnt: Workers, Soldiers, and Breeders. A complete explanation of the castes is found above in the section Types of Ants—Castes and Brood.



The castes are controlled by using a three-way "joystick." Each of the three types of ants is found at a corner of the triangle. In the middle of the triangle is the joystick that you can click and drag. If you drag it all the way into any one corner, all the new eggs will hatch into that type of ant. If it is in the exact middle, your ants will be equally divided between the castes. If you are careful, you can set your ants in any ratio of the three types.

At each corner of the triangle is a box displaying Breeders, Workers or Soldiers, and showing the percentage of ants of each type. Click in any of these three boxes to toggle between displaying percentages and actual numbers of ants. To the right of the triangle is a set of bar graphs that give you another view of how your ants are divided up between the different castes.

AUTO, MANUAL AND PRESETS

When the Auto button is depressed, the simulation automatically controls the type of ants that will hatch. It will do a fairly good job, but will not respond well to emergencies. You may also need to take control for certain strategic moves. When in Manual mode, the caste ratios stay as they are until you change them.

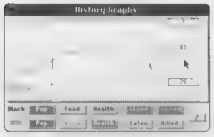
There are three Presets you can use to save favorite settings for strategic moves or emergencies. To set the Presets, drag the joystick to the setting you want, then click on any of the Set buttons. To recall the setting at a later time, just click on the same Set button.

HELP

Click and hold on the Help button to see an on-screen explanation of all controls in this window.

HISTORY WINDOW

The History Window shows various graphs of matters of life and death (to ants, anyway). There is no real time scale on these graphs, but they are useful for spotting trends in your ant colony.



Click and hold in the graph area to see actual numbers for the current value of displayed graphs.

Black Population shows the rise and fall of the number of black ants. Click and hold in the graph area to see the current number of living black ants.

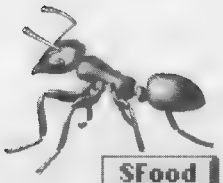
Red Population shows the rise and fall of the number of red ants. Click and hold in the graph area to see the current number of living red ants.

Black Food shows how much food the black ants have stored in their nest. Click and hold in the graph area to see the number of green balls currently in storage.

Red Food shows how much food the red ants have stored in their nest. Click and hold in the graph area to see the number of green balls currently in storage.

Black Health shows the rise and fall of the general health of the black ant colony. Click and hold in the graph area to see the current health of the colony: 0 is dead, 100 is very healthy.

Red Health shows the rise and fall of the general health of the red ant colony. Click and hold in the graph area to see the current health of the colony: 0 is dead, 100 is very healthy.



SFood

Surface Food Supply is the amount of food available in the environment (not including food in nests). Click and hold in the graph area to see the current amount of available food.

Eaten

Ants Eaten is the number of black ants that were killed and eaten by spiders and ant lions. Click and hold in the graph area to see the total number of black ants eaten so far.

Expired

Ants Expired is the number of black ants that died from natural causes. In SimAnt, the main natural cause is low health from lack of food. If your health level is 100%, no ants will expire. The lower the health, the more expirations. Click and hold in the graph area to see the total number of black ants that have expired so far in the game.

Killed

Ants Killed is the number of black ants that died at the hands (or mandibles) of red ants, or by the feet, poison and lawn mowers of humans. Click and hold in the graph area to see the total number of black ants that have been ruthlessly murdered by the bad guys so far in the game.

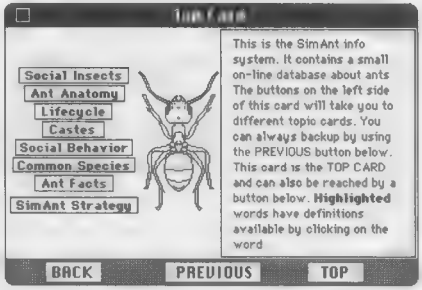
?

Help provides on-screen explanations of all the graphs in this window.

INFORMATION WINDOW

The Information Window is a mini-tutorial on real ants. It also includes some strategic suggestions for playing SimAnt. It will explain enough about ants, their societies and their behavior to help you understand what happens in SimAnt, and why it happens. It will also improve your game play. A more complete source of information on real ants is found later in this manual.

Depending on your type of computer, there may be slight differences in the appearance and operation of this window. Check your machine-specific Addendum/Quick Start Guide for details.



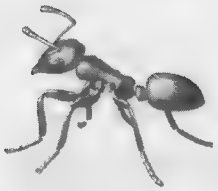
INFORMATION STRUCTURE

The information is presented in a series of electronic index cards. There are four main parts to the cards in this window: the Title Bar, the Text Box, the Picture, and the Button Bar.

The cards are arranged in an upside down "information tree." At the top of the tree is the Top Card. This card is like an index, listing the main topics available. Clicking on any of the subjects takes you to another card. Sometimes the subject cards below the Top Card also have indexes to different areas of that subject.

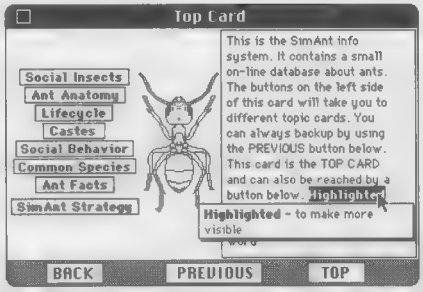
TITLE BAR

The Title Bar displays the name of the individual card.



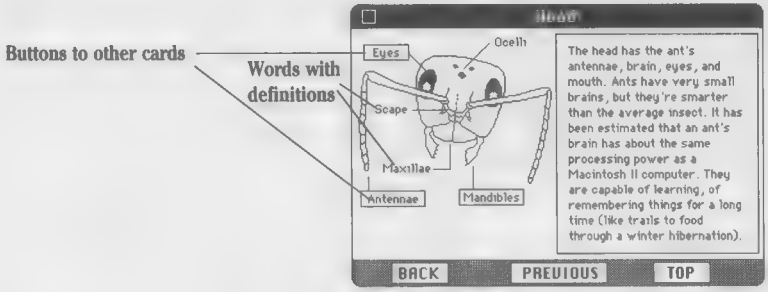
TEXT BOX

The Text Box displays text. Words that appear in bold text have pop-up definitions. Click and hold on a word with bold text to see the definition.



PICTURE

There is usually one Picture per card. There can also be words in the picture. Words that are in boxes are buttons that link to other cards. Click on the buttons to jump to the other cards. Words that are not in boxes have definitions attached. Click and hold on these words to see the definition.



BUTTON BAR

The Button Bar has three buttons for navigating through the cards.

Back returns you to the last subject index card.

Previous takes you back to the last card you looked at. Clicking on this repeatedly will step you backwards through all the cards you have looked at.

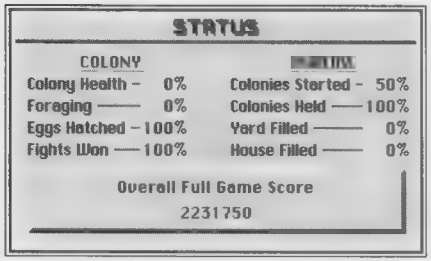
Top displays the introductory Top Card.

Sad workers are depressANTs.

SimAnt

STATUS WINDOW

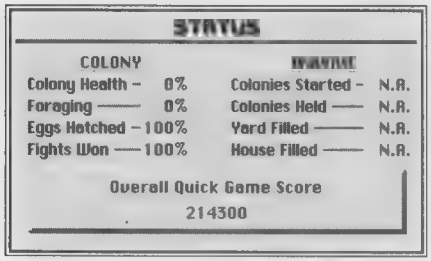
The Status Window gives you feedback on your performance as an ant. It is opened by selecting Status from the Windows Menu and by clicking on the "percent" button in the Map Window.



This window gives individual efficiency ratings in eight different categories; the four Colony ratings relate to all games, the Universe ratings relate only to Full Games. In an Experimental Game, these percentages rate the ants' performance in the face of your interference.

COLONY RATINGS

Colony Health is the average colony health over the period of the game.



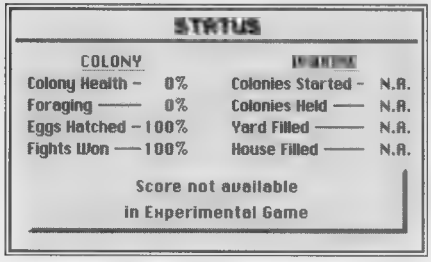
Foraging is the ratio of food gathered by the black colony to the total food gathered by both the red and black colonies. This is a direct reflection on the quality and quantity of your foragers.

Eggs Hatched is the ratio of black eggs that successfully hatch to the total black eggs laid. This is a direct reflection of the quantity and quality of nursing.

Fights Won is the percentage of fights between red and black ants that are won by the black ants.

UNIVERSE RATINGS

Colonies Started is the ratio of the black colonies started during a game to the total colonies started by red and black ants.



Colonies Held is the ratio of black colonies that survive.

Yard Filled is the percentage of the Yard Patches that are filled by black colonies.

House Filled is the percentage of the House Patches that are filled by black colonies.

OVERALL SCORE

An overall score is given for Quick and Full Games. No score is given in Experimental Games.

The overall score is calculated by weighting each of the above percentages as well as the Yellow Ant's health.

In general, you can rate yourself by the following scores for Quick and Full Games:

	OK	GOOD	GREAT
QUICK GAME	200,000	280,000	350,000
FULL GAME	2,500,000	3,500,000	4,500,000

An ant exposed to radiation becomes a mutANT.

THE OBJECT OF THE QUICK GAME

The object of a Quick Game is to destroy the red ant colony and take over that section of the backyard. You win when you kill the red queen.

THE OBJECT OF THE FULL GAME

The object of a Full Game is to take over the whole house and yard and drive out the humans. You win when you destroy all the red ants and take over 70% of the Patches inside the house.

BASIC STRATEGIES

In general, you want to gather as much food as you can while allowing the red ants to get as little food as possible. This lets you breed more, bigger, healthier ants than the red ants.

All you care about in a Quick Game is the one section of the backyard. Reproducing and starting new colonies only counts in a Full Game, so don't waste any energy producing males or new queens.

Use the Yellow Ant to take recruits to food, release them, and then look for more food.

If there is a lot of food, set some ants in alarm mode to guard it.

If the food is near the reds, and you can't get it all, try to make it hard for them, especially once their health gets low. They will be easier to defeat one-on-one that way. Use rocks to make a barrier around food to keep the red ants from finding it or accessing it easily.

Lead the spider over to the red nest.

Pick up rocks and close the opening(s) to the red nest to starve them out, or at least slow them down.

Wait until you have the red ants outnumbered and preferably out-healthed before attacking en masse.

Make your Yellow Ant a soldier whenever possible. It will win more fights.

Set the Yellow Ant's health warning high. It will need to stop more often for food, but will win more fights.

When marching off to battle, protect the Yellow Ant. It is the leader, and very vulnerable to attack. The Yellow Ant dying costs you time, since you have to be reborn and return to the fight. Plus, all the recruited ants are released when the Yellow Ant dies, and the attack stops.

As your army of ants approaches the enemy, repeatedly transfer the Yellow Ant to an ant near the rear of the army, and bring it forward.
Watch the enemy carefully and try to pick out the Red Terminator. If they are attacking, or on their way to meet you for battle, destroying the Red Terminator will disperse all its recruited ants.
Sneak into the red nest and dig lots of deep holes. The red queen might go too deep and drown in the next rain.
Placement of new colonies can be important in a Full Game. You have to make your way to the house so you can take it over, but you also have to keep the red ants under control. While the colonies in Patches that aren't active are being simulated in the background, red colonies that are surrounded on four sides by black colonies are easier to invade with a newly founded colony.
Occasionally, you may need to sacrifice a colony by gathering a lot of food, and setting all energy to making breeders. You will get lots of new queens to place, but your colony will be greatly weakened and may die.

EXPERIMENTAL STRATEGIES

THE OBJECT OF THE GAME

The object of an Experimental Game is to play with a bunch of electronic ants with a number of tools and chemicals.

ADVANTAGES OF ELECTRONIC ANTS

Electronic Ants are easier to get rid of than real ones, and they don't make stains when you squish them.

THINGS TO DO IN EXPERIMENTAL GAMES

You've got a free hand here. You decide if and when you win. Just have fun and see if you can find some insight into the mind and soul of the ant.

CHEMICAL TESTING

Test the ants' reactions to and use of the various trail and colony marker scents.

For example, you can test the directionality (or lack thereof) of trail markers. Make a long trail marker scent path that leads from a colony

entrance to some food. Drop ants one at a time in the middle of the trail. See how many go towards the food and how many go home.

RUNNING MAZES

Run ants through mazes. See if they find their way out quicker than they found their way in. Repeat the maze and see if they learn.

GLADIATOR BATTLES

Build an arena filled with ant lions. Build a little wall around some food in the middle of the arena with only one small opening. Set loose one or two each of red and black ants. Pretend you are a Roman. Enjoy the carnage. Throw in a spider to add to the thrills.

GENERAL YUCKINESS

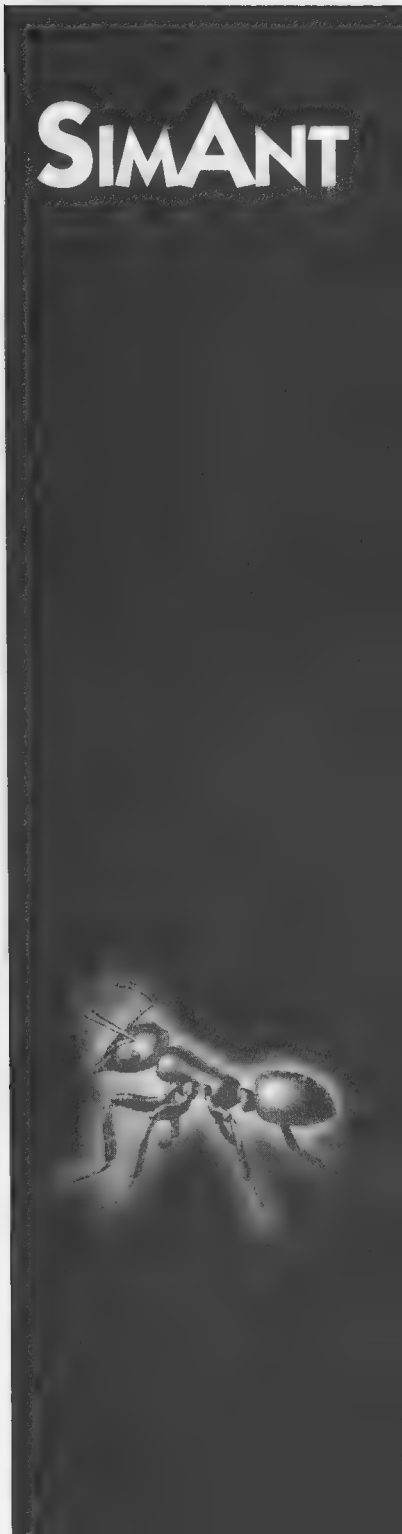
Show what happens to us when we die and gross out your friends and family. While Paused, dig out the shape of a human underground, fill it with ants, get someone to look, then Unpause it. (The ants crawl in, the ants crawl out...)

SEE YOUR NAME IN ANTS

Spell your name in trail scent and watch it come to life.

PART 2
REAL ANTS — BACKYARD BACKGROUND

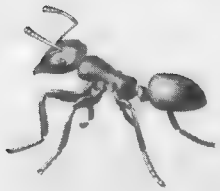
They taste salty.
— Cassidy Wright



SIMANT

EXTENDED TABLE OF CONTENTS

PART 2: REAL ANTS — BACKYARD BACKGROUND



INTRODUCTION

Ants live everywhere on earth except the coldest and highest spots on the planet. They live in deserts, jungles, swamps, cities, mountains, boats, airplanes, and houses—there is even a recently discovered species of ant that only lives in government buildings in Washington, D.C.

Ants are amazing little creatures that do things you may have thought only humans do, like dairy farming: keeping herds of aphids as "cows" and "milking" them for food; vegetable farming: growing underground gardens for nourishment; career specialization: often changing careers a few times in their lifetime; childcare: taking care of their young by protecting and feeding them; and education: older, more experienced ants work with the younger ants, teaching them the tricks of the trade.

Ants also do things you wish humans wouldn't, like: living in a constant state of war with other ants; and enslaving other ants, making them work and even fight for their masters.

They also do things you hope no human would do, including: eating dead enemies after a battle—even the enemies' eggs and babies; and eating their own old and weak, and even their own eggs during times of food shortages.

THE ANTS' PLACE IN THE WORLD AND ECOLOGY

Ants are small, but they are among the most important creatures on earth. They are important to the cycles of life. They move at least as much soil as earthworms. They bring plant material deep into the earth and enrich the soil. Ants that make their nests in dead logs speed the process of decay and hurry the returning of the nutrients in the wood to the soil. They collect seeds, and the ones they don't eat grow into new plants. They pollinate some plants. Ants are among the leading predators of other insects and small invertebrates, including other ants.

Ants also cause damage. Carpenter ants can damage wood homes and buildings. Leaf-cutter ants can wipe out farms. Fire ants can also cause problems for farmers, as well as cause pain to humans they bite. By tending aphids, ants encourage them to do crop damage.

WHAT WE CAN LEARN FROM STUDYING ANTS

Besides learning about ants themselves, and increasing our general knowledge of entomology* (the study of insects) and myrmecology* (the study of ants), learning about ants can give us insight into biology*, sociology*, sociobiology*, evolution*, behavioral studies, and more.

Biology — Ants' bodies are relatively simple, and are easier to study and understand than more advanced life-forms, yet they are still complex, with complicated chemical control and communication systems.

Sociology and Sociobiology — Ants are social insects. Their primitive societies can give us insights into the origins of human societies.

Evolution — Since there are so many species of ants with so many physical and behavioral differences in various stages of development, they are a living laboratory for studying evolution.

Behavioral Studies — Ants have developed complex group behaviors that are a combination of instinct and learning.

More — Ants can teach us many things far removed from the ants themselves, or even insects in general. Ant colonies are now being studied as models for human cities and societies, as models for computers, and even as models for the human brain.

ABOUT THIS REAL ANT SECTION OF THE MANUAL

This section of the manual, combined with the on-line Help in the SimAnt program, will give you a basic understanding of ants. Much of the information presented here will help in your game play. This manual goes into far more detail than the on-line help. There is also an extensive bibliography and reading list at the end of the manual for those who want to learn more.

There are thousands of ant species, and each one has a different physical appearance and different behaviors. This manual and the on-line Help will only deal with the most common behaviors and species, plus a few of the less common but most interesting species. Keep in mind that there are a lot of known types of ants in the world that aren't mentioned here—and many that haven't been discovered yet.

Throughout this science section, there will be some big, difficult, and scientific words. They will have an asterisk [*] after them, and will be defined in the glossary at the end of this book.

ANTS, HUMANS, SCIENCE, AND HUMOR

Ants are very different from humans. They have no sense of humor. They have no hopes or fears. They have no mercy. They have no morals. Their only reason to live is to ensure the survival of the colony, even at the cost of many individuals' lives. The life of an individual ant means very little to the colony, and very little to the individual.

Yet, in some ways, ants and humans are alike. We want to survive. We take care of our young. We teach our young by example. We both practice prenatal care. We both clean, maintain and take care of ourselves and our homes. These differences and similarities make a good framework for understanding ants and our relationship to them. But when you closely compare and contrast creatures as different as humans and ants, a number of funny situations are bound to arise.

In general, science has been a very serious matter, with little room for humor. Not any more. This book is spattered with cartoons and bits of silliness to make points on just how different—or similar—humans and ants really are. Many of the cartoons won't be funny unless you understand the background facts about ants. (Don't blame me if it's not funny. You just didn't read the whole chapter.)

ANTS — GENERAL INFORMATION

INTRODUCTION

The combined weight of all the ants on earth is greater than the combined weight of all the humans on earth. It's not really a surprising statement when you consider that, other than the polar regions and the highest mountaintops, ants live everywhere on the planet. It's even less surprising when you consider that ants are the most numerous insects—and the most numerous animal—on earth. While not surprising, it is a little overwhelming, even a little scary, when you consider that it takes approximately 500,000 ants to add up to a single pound.

Ants are one of the oldest living creatures in the world. Ants are like sharks: they haven't physically changed much in millions of years. Nature came up with a near-perfect design, and left well-enough alone. That ants are still successful after at least 60 million years is proof of the old axiom, "If it ain't broke, don't fix it."

Ants are the strongest creature in relation to their size. Ants can carry 10 to 20 times their body weight, and they will work together in small or large groups to move extremely heavy things.

Ants are the longest living insect. Workers, on the average, live about one year. In some species they can live for four to five years. Some queens live longer than 20 years.

Ants are everywhere. At any given moment there are at least 10^{15} living ants on the earth, .1 percent of a total of 10^{18} total insects. The biggest ant colony found so far is on the Ishikari Coast of Hokkaido: 306,000,000 ants, with 1,080,000 queens in 45,000 interconnected nests over an area of 2.7 square kilometers. Ants are so numerous in the South American jungles they have been called "The King of Brazil," and "The actual owners of Brazil." Brazil has also been called "One great ants' nest."

Ants are highly adaptive to their environment. When moved to a different climate or location, they quickly adapt. There are specially adapted ant species that only live in and around human dwellings. Some ant species can survive under water for up to 14 days or longer by going into something like suspended animation. Ants are resistant to hard

radiation, and some ant species are highly resistant to industrial pollution. If a nuclear holocaust ever destroys our civilization, the ants will be giving the cockroaches a run for their money.

Ants modify their environment. They regulate the temperature and humidity within their nests. They control airflow through their nests. They build mounds. They clear pathways.

Ants modify themselves. Through a complex system of chemical communication and constant feedback, an ant colony regulates the amount of workers and soldiers, and controls the timing of production of males and fertile females. In some species, when food is plentiful, young adults are fed and fed—stuffed until they get big and fat and become living food-storage containers.

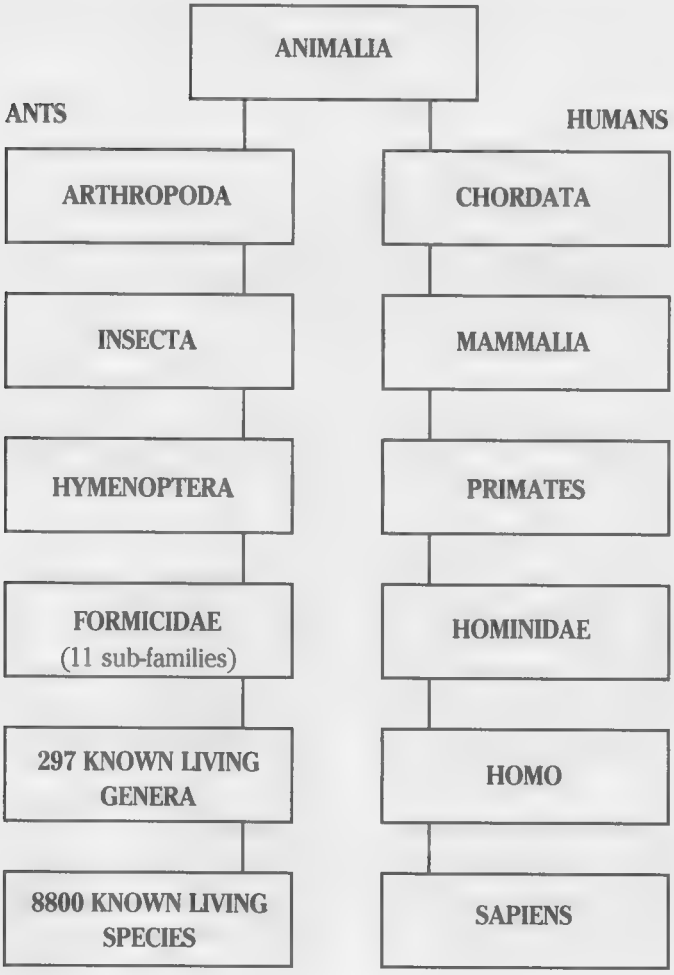
Ants are vicious, merciless survival machines. They breed special castes of large, powerful soldiers. Along with the soldiers, workers will fight for the survival of the colony, not giving a thought for personal safety or survival. Some ants even use chemical propaganda in warfare. When ants fight, there is no surrender, no mercy, no peace. They kill all the enemies and eat their babies. If it is necessary to the survival of the colony, ants will eat their own babies. Some ants steal the eggs and larvae of other species and raise them as slaves.

Ants are arguably the most successful creatures in the world. They are so numerous, and survive so well in so many places—why haven't they taken over the world? Because they eat each other.

We should study ants. You can't knock success. If you want to learn how to do something, study someone who does it well. When it comes to survival, ants are the proven experts. And, as mentioned before, studying ants may give us insights into the workings of evolution, the origins of society, group cooperation methods, computers, human brains, cities and societies. Scientists who specialize in the study of ants are called myrmecologists, from the Greek word for ant: *myrmekos*.

WHERE ANTS (AND HUMANS) FIT IN THE CLASSIFICATION OF ANIMALS

Within the taxonomy* of animals, ants are classified as a single family, the Formicidae, within the order Hymenoptera, which includes bees, wasps, sawflies, ichneumons, and others. There are 11 subfamilies, 297 genera, and over 8800 known species of ants so far—there are undoubtedly many more.

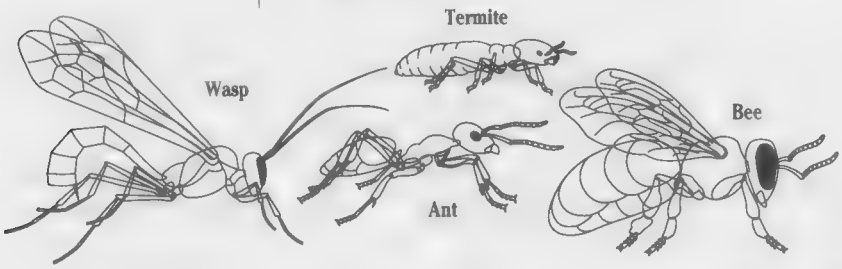


ANTS ARE SOCIAL INSECTS

SOCIAL BEHAVIOR

Social behavior—cooperation between more than one member of a species—has proven to be an excellent survival trait. It can be considered one of the greatest achievements of organic evolution. Practiced by many diverse species, social behavior has evolved in a number of different directions. There are four groups of animals that have attained levels of social evolution far above all others:

Colonial Invertebrates, including corals;
Social Insects, including some bees, some wasps, all termites, and all ants;
Nonhuman Mammals, including apes and wolves; and
Humans.



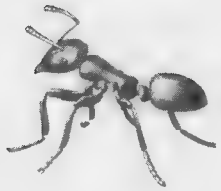
The Social Insects

Each of these social groups can be the subject of many books, but this particular book will focus on only one member of the social insects—the ants.

Ants can be considered the premier social insects. They are the most widely distributed, living from the Arctic tree line to the southern tip of Africa. They are the most numerous of the social insects. They have more genera and species than all other social groups combined. They have adapted to more different habitats than any other animal. Ants have developed socially in many ways—including practicing slavery.

LIFE, SOCIAL INSECTS, AND US

All living things, including humans, are made of the same material as rocks, rivers and dirt. The difference between us and 100 pounds of mud is the way the stuff we are made of is organized. This organization is very complex and occurs at many different levels. The study of a social insect



colony sheds light on all the levels of organization, from the molecular level to the society level. In many ways it tells us about ourselves.

The social insects' society is organized at a lower level than human societies because they have tiny brains and no culture, but at a higher level than human societies in cohesiveness of society, caste* specialization and individual altruism*.

The social interactions of ants are much simpler and easier to study than that of humans, but have parallels that may give us information on the origins of human society (the study of ant societies led to the study of sociobiology).

SOCIAL INSECTS: SUPER-ORGANISMS

Social insects are sometimes referred to or thought of as Superorganisms* because so much of their social behavior seems to simulate, or serve the same purpose as, an animal's organs and tissues.

In the case of ants, the reproductive castes are like the superorganism's reproductive organs, the worker caste is like the superorganism's muscles, the process of sharing food by trophallaxis* simulates a circulatory system, etc. You can think of a social insect colony as one spread-out organism that forages the territory like a huge ameba.

The concept of superorganisms will be covered in detail later in this book.

SOCIAL INSECT TRAITS AND LEVELS OF SOCIAL BEHAVIOR

Social insects have three distinctive traits:

1. Individuals of the same species cooperate in caring for the young.
2. There is a reproductive division of labor, with sterile individuals working on behalf of fertile individuals.
3. There is an overlap of at least two generations in life stages capable of contributing to colony labor (i.e., not egg, larva, or pupa, which do not do any work).

There are also presocial insects at various levels of social behavior. Following is a definition of the range of social activity among insects.

Solitary — showing none of the three traits above.
Subsocial — the adults care for their own nymphs or larvae for some period of time.
Communal — members of the same genration use the same composite nest without cooperating in brood care.
Quasisocial — members of the same generation use the same composite nest and also cooperate in brood care.
Semisocial — like quasisocial, but there is also reproductive division of labor (a worker caste cares for the young of the reproductive caste).
Eusocial — like semisocial, but there is also an overlap in generations: offspring assist parents. This is the most advanced stage of social behavior in insects.

NONSOCIAL AND PRESOCIAL INSECTS/ ARACHNIDS

Butterflies, like most insects, are nonsocial, or solitary. Males and females meet to mate, but there is no other cooperation between individuals. Eggs are laid and abandoned. They are not tended or cared for. Eggs hatch into caterpillars, the larval stage, which wander about on their own and eat whatever they can find. The caterpillar eventually spins a cocoon and pupates into the adult butterfly, which will have no social cooperation with other butterflies, and little contact other than mating to begin the cycle again.

Insects aren't the only arthropods* that have social behavior. Some arachnids (spiders) have reached the quasisocial level. A West African spider, *Agelena consociata,* lives in large groups in communal web-nests. Small prey that get caught in the web are captured and eaten by individual spiders, but larger prey are attacked and killed by cooperative groups. The adult spiders will surround the intended meal and attack, while the smaller, younger spiders wait nearby and watch. As the older spiders die off, their place in the front row of battle is taken by younger spiders that have watched and learned from their elders. The young are cared for by the community, and individual parents show no preferential treatment to their own offspring.

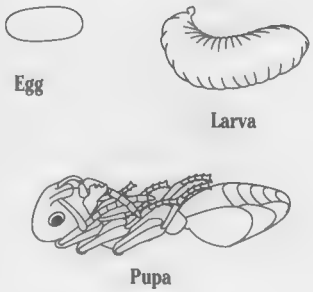
INDIVIDUAL ANTS

Ants and their place in the world are best understood if they are studied at the colony or superorganism level. But before looking at them in groups, let's get to know them individually, up close and person-to-insect.

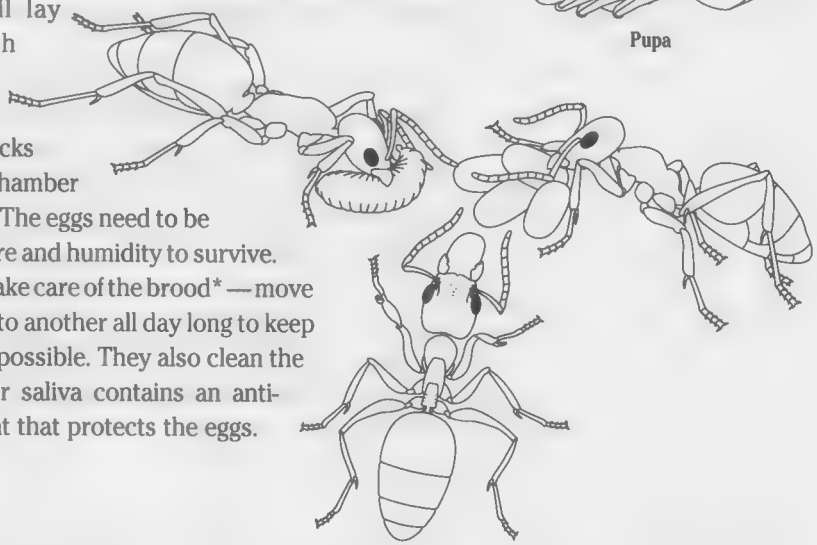
There are so many different species of ants, with so many physical and behavioral differences, that all the possibilities can't be covered here. We'll try to cover the most common ranges of ants, and point out some of the most interesting exceptions.

THE INDIVIDUAL ANT LIFE CYCLE

Ants, like most insects, live parts of their lives in two completely different forms: larva and adult. Ants start out as eggs that hatch into larvae—grublike wormy things that don't resemble adult ants in shape or color. Then they pupate*, and change into the adult ants we know and love.



Queens can lay from 10 to hundreds of eggs per day. Depending on the species, queens produce from as few as 400 on up to 50,000,000 eggs per year. The queen has a special chamber in her body that feeds and preserves for many years the sperm she received during mating. As eggs are laid, they are usually fertilized on the way out. Fertilized eggs become female ants. At special times in the colony lifetime, and in limited numbers, the queen will lay unfertilized eggs, which become males.



As the egg is laid, a worker picks it up and takes it to a special chamber in the nest called a nursery. The eggs need to be kept at a specific temperature and humidity to survive. Nurses — worker ants that take care of the brood* — move the eggs from one chamber to another all day long to keep the eggs as close to 77 F as possible. They also clean the eggs by licking them. Their saliva contains an anti-bacterial or anti-fungal agent that protects the eggs.

Larva

After about 14 days, the eggs hatch and become larvae (pronounced *lar-vee*). Larvae have no legs or eyes. They look like tiny white worms with mouths. Nurse worker ants feed the larvae. Depending on the species, larvae are fed either dead insect parts or regurgitated food that has already been eaten by the nurses.

The larvae also feed the nurses. They spit up some sweet juice that the nurses like. This reinforces the nurses' behavior to take care of the larvae, and also allows the larvae to send chemical messages back to the queen. (More on this in the communication section.)

For the next 8 to 20 days, the larvae grow very quickly. When their skin gets too tight for them, they burst open and crawl out of their skin. They do this four or five times. Each time they do this, they get larger and develop more. Each of these larval growth stages is called an instar*. A larvae that has shed its skin twice is considered in its third instar.

Pupa

After the fourth or fifth instar, the young ants-to-be pupate and become pupae (pronounced *pew-pee*). They do this by spinning a cocoon* around themselves (although some species don't spin cocoons). The pupae in cocoons look like larger eggs, and are often thought to be eggs by people who didn't read this book. The actual ant eggs are almost too tiny to see and are kept very deep in the nests.

The cocoons are cared for by the nurses. They don't need feeding, but they do need temperature regulation and are carried from chamber to chamber all day long. After two to three weeks in the cocoon, the pupa has transformed into an ant. It will gnaw a hole in the cocoon, then the nurses will help them to widen the opening and to eclose*—emerge from the cocoon.

The young adult ants, known as callows*, will be soft and vulnerable for a few days, and their color will be very light. But soon, they harden, toughen, and darken. Ants emerge from the cocoon full-sized adults, and never grow any bigger.

The total "childhood" of the ant, from birth of the egg to the eclosion of the adult ant, is (for most ants) between 20 and 75 days.

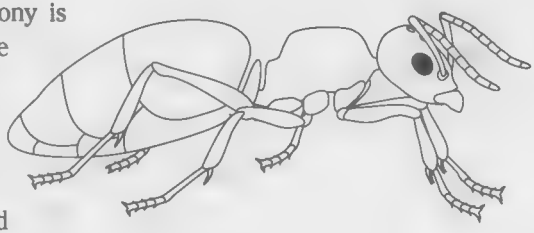
CASTES

Within ant societies there are different sizes and shapes of ants, called castes. There are three main castes of ants: Queens, Males, and Workers. These castes are specialized both in their physical shape and their behavior for certain tasks that ensure the survival of the colony. Many species also have a Soldier caste, and/or multiple Worker castes. Ants are polymorphic*, meaning that there is more than one caste within one sex: the queens, workers, and soldiers are all females.

Queen ants only lay two types of eggs, female and male. All female eggs are identical when laid. The care and feeding the immature ant receives from the nurses determines whether the female will be a worker, a soldier, or a new queen.

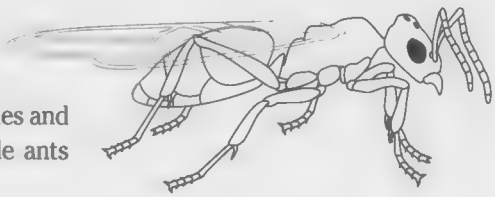
QUEENS

Queens are fertile females that, once a colony is founded, do very little but lay eggs. There can be one or many (even thousands) active queens in a colony. Queens are the longest-lived caste, some living more than 20 years. Queens of most species have wings when they first mature to adults, flying to mate and start a new colony.

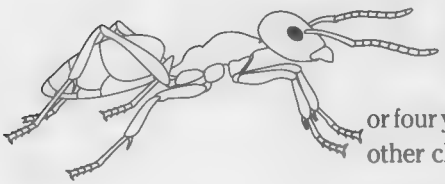


MALES

Male ants are the shortest-lived caste, some living only a few weeks. Males don't do any work around the nest. They only live to perform one task—mate with the fertile females and propagate the species. Most species of male ants have wings used in mating flights.



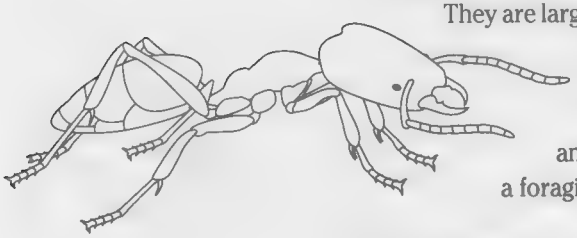
WORKERS



Most ants are workers, which are sterile females. The workers do most of the work around the colony. They dig tunnels, take care of the brood (the young ants—eggs, larvae and pupae), find food, feed the queen and other ants, and fight. Workers, on the average, live for about one year (workers of some species can live up to three or four years). Some workers perform the same task for their entire lives, other change tasks.

It is really the workers—not the queen—that rule the colony. They have slightly bigger brains, more mobility, and far more numbers.

SOLDIERS



Soldiers are also sterile females. Not all species have a soldier caste. They are larger than the workers, and have big heads and strong jaws. Some soldiers, who have large, flat heads, act as doorway guards—or, more accurately, as doors. They plug openings to the nest with their heads, and only move when they receive the right signal from a foraging worker.

Since soldiers do work other than fighting, they are sometimes called Major Workers, and the other, smaller workers are called Minor Workers.

OTHER CASTES

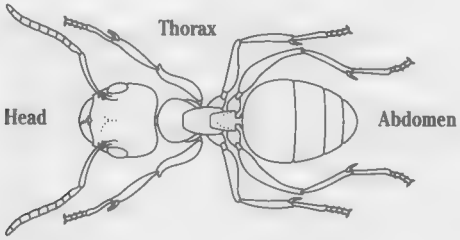
Soldier Blocking Nest Entrance

In some species, there are more than the two usual castes of sterile females (workers and soldiers). The *Pheidole tepicana,* for example, has six different worker castes.

BASIC ANATOMY

GENERAL INFORMATION

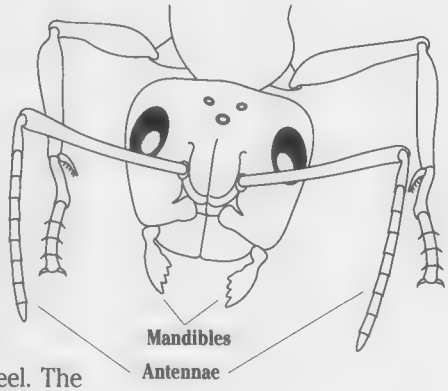
Ants, like all insects, have a hard covering around their bodies made of chitin*, called an *exoskeleton**. Also, like all insects, they have three body parts, the head, the thorax, and the abdomen.



Ants don't have lungs. They have air tubes through their bodies, called *tracheae,* through which they absorb the oxygen they need. Ants don't have ears, but they do have organs on the legs, head and thorax that can sense vibrations. Most ants don't make noises, and you can't hear them walk unless you have a very bad hangover. Some very primitive ants can and do make sounds by rubbing parts of their bodies together. We don't know for sure why they do this.

THE HEAD

The head has the ant's antennae, brain, eyes, and mouth.



THE ANTENNAE

The antennae are the ant's primary sense organs, and are used for touching, smelling, and feeling vibrations. The antennae are jointed, or elbowed, and are made of two parts.

The lower part is the *scape**. The upper, segmented part is the *funiculus**, which contains the sense organs that smell and feel. The antennae are in constant motion, and are stereoscopic: the ant can tell the direction of an odor by the relative strengths of the odor hitting each antenna. If you cut off one antenna, it loses this ability.

THE BRAIN AND NERVOUS SYSTEM

Ants have very small brains, but they're smarter than the average insect. It has been estimated that an ant's brain has about the same processing power as a Macintosh II computer. They are capable of learning, of remembering things for a long time (like trails to food through a winter hibernation), and actually have limited free will.

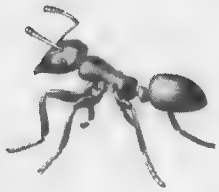
Ants have nerve chords that reach from the brain to the rear of the ant. The nerve chord has enough processing power that each of the three main segments of the ant are somewhat autonomous. That is why you can cut off an ant's head and it will still walk around until it starves.

Ant brains have mushroom-shaped parts composed of nerve cells. These correspond to what we call "grey matter" in human brains. This is the part of the brain where memory, learning and instinct patterns are stored and implemented. If you cut out this part of the ant's brain, it's like giving a human a lobotomy.

The brain is very poorly developed in male ants, is more developed in queens, but is largest and best developed in the workers, who need it for their colony building and foraging activities. Soldiers, even though they have bigger heads than the workers, don't have bigger brains. Their heads are filled with extra muscle that is needed to control the extra-large mandibles.

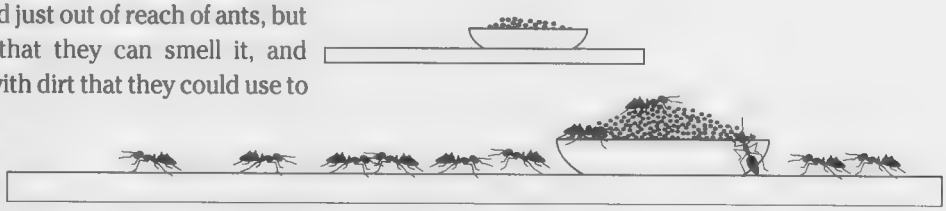
Most insects live very short lives, and don't have the time (or brainpower) to learn. They are born with all the knowledge they need. This knowledge is known as *instinct**, and has to do with the basic necessities of life, such as eating, mating, defense and nest-building. Acting on instinct is reflexive. When faced with a certain stimulus, the insect acts a certain way. No thought is involved. Ants live longer than most insects, and have time to learn. They also have bigger brains than most insects. Part of the ant's overall success and adaptability must be due to the fact that they can learn new behavior to augment their instinctive behavior.

Ants can learn, but they can't really think. They can remember, but they can't reason or solve problems. They can run mazes, find their way



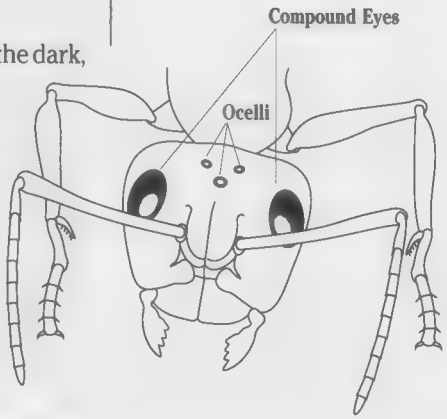
through by trial and error, and remember the way so that the next time through they go faster. They can become accustomed, or habituated, to unusual circumstances such as being handled or constant nest disturbances. They can remember landmarks in their foraging area. But they can't solve a simple problem that can be solved by a combination of skills they already possess and a little logic.

If you place food just out of reach of ants, but close enough that they can smell it, and provide them with dirt that they could use to build a mound or bridge to reach it, they won't ever get to the food. Even though they know how to build mounds out of dirt, they can't solve the problem by applying a behavior for one situation to another situation.



THE EYES

Even though many ants spend their entire lives underground in the dark, all ants have compound eyes. These eyes are like flies' eyes, and have many facets. Because of these compound eyes, ants can see moving things better than stationary things, and can see movement better when they are standing still. That is why, when foraging, they walk for a while, stop and look around, then walk again.



Males have more facets in their eyes than females. They need the extra sight for the mating flight.

Males and queens also have three simple eyes on the top of their heads called *ocelli*. These eyes distinguish between light and dark.

All ant eyes are fixed; they don't swivel or turn. Ants must turn their head to look in another direction.

THE MOUTH

The mouth consists of mandibles and maxillae. Mandibles are the big jaws that move from side to side. They are used for fighting, digging, and carrying things. The maxillae are behind the mandibles and are smaller. They are used for chewing food, and for cleaning legs and antennae.

Ants have a well-developed sense of taste. With their sense of taste and smell in different places (mouth and antennae, respectively), it can truly (and uninsultingly) be said that their only taste is in their mouths.

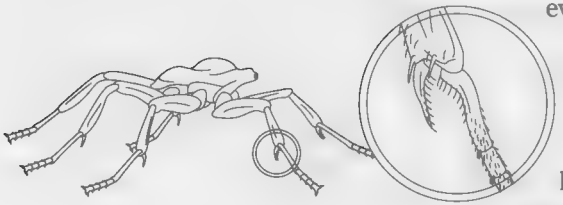
Ants eat by chewing food with their maxillae, and putting it in a pouch below the mouth opening. This pouch is called the *infrabuccal pocket.* Muscles that surround the pouch squeeze the liquid out of the food. Ants swallow the liquid and spit out the solid parts. The swallowed liquid goes to the *crop** for storage.

GLANDS

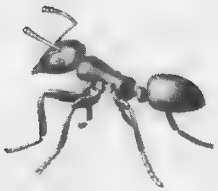
The ant's head also contains various glands that produce chemicals necessary for the ant's survival, as well as for communicating with other ants.

THE THORAX

The thorax is the middle section of the ant. The ant's legs are all attached to the thorax. Ants have six legs. At the bottom of each leg is a foot. Each foot has two hooked claws that let ants walk on walls, climb trees, and even walk upside down. Near the foot of the ant is a "hook" with hairs inside it. The ant uses this like a comb to clean its antennae and legs.



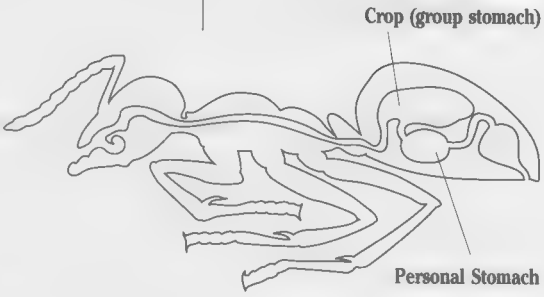
In many species, the thorax also contains the ant's heart, a tubular muscle that contracts and forces the blood through the body cavities. Other ants' hearts are in their abdomens. Ants don't have blood vessels; the blood just washes through the body bathing the tissues directly. Ant blood is colorless.



THE ABDOMEN

The abdomen is the ant's rear end. It is made up of the *petiole** (waist) and the *gaster** (everything else).

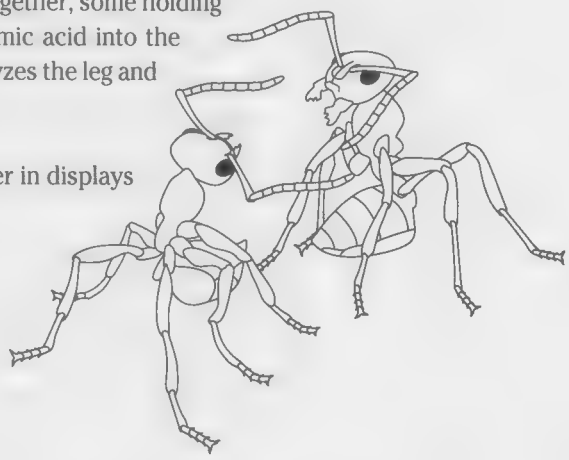
The gaster contains the crop and the intestine. The crop is the group stomach, a storage place where ants keep the food that they bring back to the nest for sharing with others. The intestine is the personal stomach and digestive system for food that is absorbed and digested by the ant.



The gaster also contains glands that produce various chemicals, including formic acid, pheromones* to leave trails to food for other ants to follow, and other chemicals that send messages to other ants.

Some ants have stingers at the ends of their gasters. They can sting enemies and inject them with poison. Some ants that don't have stingers can still squirt formic acid or some other venom out of the end of their gasters when they are attacking or defending. (Humans use formic acid as an insecticide, an antibiotic, a food preservative and a disinfectant. At one time red ants were harvested for formic acid, but now it is artificially made.)

When attacking a larger prey, ants will work together, some holding the enemy's leg still and others squirting formic acid into the joint where the leg meets the body. This paralyzes the leg and cripples the prey.



Ants will often point their gasters at each other in displays of aggression, of threat, and during battle.

ANT COLONIES

Now we'll look at the colony as a whole. The most fascinating thing about ants is how intelligent group behavior emerges from the very simple, non-intelligent behavior of the individual members. As pointed out before, it is helpful in the understanding of ants and their place in the world to think of an ant colony as one large, spread-out animal.

With over 8800 species of ants, which have been developing for at least 60 million years, the variety of ants, ant colonies, and their nests is immense. In this book we'll deal with the most common types, and mention a few of the less common but interesting ones. Keep in mind that there are many variations not mentioned here, and many not yet discovered by scientists.

GENERAL INFORMATION

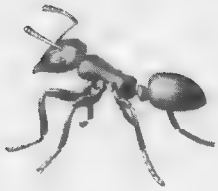
A group of ants living together is called a *colony.* The place they live is called a *nest.* The number of ants in a colony depends on the species of ant and the age of the colony. Colony populations range from a few dozen members to millions of ants. A nest colony with only one queen is called *Monogynous**. A colony with multiple queens is *Polygynous**.

Ant societies are almost entirely female, and most of the females are sterile. Males and fertile females are produced only at certain times, and only for the purpose of reproduction.

NESTS

Since ants live in so many different places, climates and habitats, their homes vary in style and architecture to match their location and situation. Ants live in holes in the ground, sometimes as deep as six meters or more; in mounds they build above ground; under rocks; in trees or plants; and in walls and even in foundations of human dwellings. Some ants make homes out of their own live bodies.

Ant nests are generally simple and irregular, taking little time, and using little or no valuable materials. If necessary, ant nests can be deserted and rebuilt without too much difficulty. In spite of the simplicity of an ant nest—as compared to a beehive—they have been built and refined through millions of years of ant evolution, and are very functional.



Nests in the ground are constructed so even the lowest chambers get fresh air. The anthill—the mound of dirt above the ground above an ant colony in the ground—helps regulate the temperature in the nest. The more surface area the anthill has, the more heat it absorbs from the sun. These mounds will vary in size and shape depending on the climate and presence of shade trees nearby.

Besides constructing the anthill to absorb heat from the sun, ants themselves supply some of the heat for the colony. In the spring, when the workers start foraging outside the nest, they will warm themselves in the sun, then return to the nest, bringing in warmth. When others notice the warmth, they go out and do the same. Ants also protect the nest from cold by blocking entrances to the outside with dirt, or even their bodies.

If an ant nest gets too warm and dry, the ants will dry up and die. Ants will search for water and bring back drops in their mandibles to keep the humidity at a safe level.

COLONY LIFE CYCLE

The ant colony life cycle, like the life cycle of any other organism, follows the sequence of birth, growth, maturation, and reproduction.

This process can be viewed as a series of energy investments. The colony grows and matures as workers are multiplied and energy (food) is stored. The colony reaches full maturity when it becomes profitable to divert some of the energy into reproduction by making new queens and males. Depending on the species of ant, this point can come when the total population is anywhere between a few dozen and hundreds of thousands. It takes a lot of energy to grow and feed the males and new queens, who are generally larger than the workers, require more food, and do little or no work or food-gathering for the colony. If males and queens are produced too soon, the colony will die from lack of food and the new fertile ants might not live long enough to make their mating flight.

It is to the advantage of the species to reproduce as often as possible to spread the species' genes, but not before the colony can afford the massive energy output necessary to reproduce. The life cycle of an ant species is the story of how the maturation point is reached with maximum speed vs. freedom from risk.

THREE STAGES OF COLONY GROWTH

There are three stages in the growth of a colony: founding, ergonomic, and reproductive.

The founding stage begins with the nuptial flight, when the virgin queens and males leave the nest and mate. The inseminated queen finds a suitable nest site and constructs a first nest cell. Then she lays eggs and rears the first brood of eggs to larvae and then to full workers.

The ergonomic stage is the growth stage. Once the workers from the queen's first brood reach the adult stage, they begin to forage and enlarge the nest, and take over the job of brood care so the queen can spend all her time and energy laying more eggs. This stage can last from one warm season to five or more years, depending on the species.

The reproductive stage is when the colony begins to produce new queens and males that go out and found new colonies, and it all starts over again.

THE FOUNDING STAGE

THE NUPTIAL FLIGHT

In a nuptial flight*, the males and virgin fertile females usually emerge from the nests and fly together. Hundreds or even thousands of females are sometimes released from a single nest in only an hour. There are also many males released, but not nearly as many as females.

The workers of the colony control the onset of the nuptial flight. They will physically keep the males and fertile females in the nest until the time is right. We still don't understand what controls the timing of when and why the workers release the young lovers. Also not understood is the fact that in many (but not all) species, mating flights seem to be

synchronized between multiple colonies, and males and fertile females are released simultaneously from many nests in an area. The advantage of this synchronization is understood: a better spreading of genetic material. It is the mechanism or signal that causes the release that we don't know.

Most of the flying ants, both male and female, die within hours of leaving the nest, even before they have a chance to mate. Many are eaten by predators, including birds and spiders. An ant nuptial flight is a gourmet banquet for birds.

Mating, depending on the species of ant, can occur in the air or on the ground, or begin in the air and end up on the ground. In some species the females will mate with only one male, and in others with a number of males, increasing the genetic diversity of her new colony.

There are two basic methods, or syndromes, that ants follow when they mate. The first is the *female-calling syndrome**. This is usually practiced by species whose colonies are relatively small at maturity (20 to 10,000 workers), and that produce relatively few reproductives (males and fertile females). In these species, the males have wings, but the females are often wingless. The females do not travel far from the nest. They stand on a high spot of ground or on a plant, and release sex pheromones into the air to call the winged males to fly to them. These flights do not seem to be synchronized either within the colony in question or with any other colonies.

The other main syndrome is the *male-aggregation syndrome**. Males from many colonies gather at specific mating sites, and either hang out on the ground or on plants, or fly around in a group and cruise for females in the air. The females fly into the swarms and mate, often with more than one male. After mating, the inseminated queens disperse over a large area to found new nests—if they aren't eaten. This method is used by species with large colonies, containing from several thousand to over a million workers, and that produce hundreds to thousands of reproductives yearly. These flights are well-timed, at the colony level and with other colonies of the same species.

LOVE AND ROMANTS

After mating, males serve no useful purpose for the colony, and they never return. Sometimes the female will kill the male right after mating, but if he's lucky, he can crawl off and live for up to three days.

Don't think that just because thousands of virgin queens are released from nests to mate that there will be thousands of new colonies after every nuptial flight. Very few queens successfully found new colonies. To survive, the queen must avoid enemies, mate (many males are eaten), make sure to mate with a male of the same species, get safely to an existing nest that will accept them or make a new nest and have the energy to lay eggs and raise a brood.

COLONY FOUNDING

After sucessfully mating and avoiding the many dangers, a queen can either rejoin her old nest, join another existing nest, or start a new colony.

Queens can sometimes find their way back to their old nests. Depending on the species and the local food supply, the returning queen may be accepted or turned away. They are sometimes accepted into another nest of the same species of ant.

Another way queens can move into existing nests is through the practice of slavery. Queens of some species can sneak, trick or fight their way into a nest of another species, kill the original queen and take over. This will be explained in more detail in the section Types of Ants.

Often, the queen must found a new colony, which isn't easy. The inseminated queen must avoid being eaten and must find a safe place. She will then scrape against a rock or other handy surface to remove her wings, dig a very small nest, and seal herself inside. Once inside, most queens never emerge, even to find food. She has to live by burning off the food stored in her body, including the muscles that once powered her now-missing wings, until the first brood matures and can go out into the world and bring her back some food. Not only does she have to keep herself alive without any extra food, she has to feed her larvae from her

own bodily energy supply. Once inside the nest, the queen will lay a few eggs, and care for them as they mature from eggs to larvae to pupae to adults.

This type of colony founding, where the queen seals herself off in a chamber and rears the first brood in total isolation, is called *claustral**, and is the most common. In some species, queens will occasionally forage outside their cells for food. This is called *partially claustral** colony founding.

New colonies can also be founded by older, larger colonies splitting up. Called *swarming*, two or more forces of workers will separate, each with at least one queen. There are two main types of swarming: *budding*, when the workers depart from the main nest with one or more queens and start a new nest; and *fission* (used by army ants), where portions of the colony containing fertile queens separate and both go their own ways.

THE ERGONOMIC STAGE

The Ergonomic Stage, also called the Exponential Stage, begins in a new colony when the first workers mature. These first workers are often small because of the limited food supply that the queen has to produce the eggs and raise the larvae to maturity. These small workers are called *nanitics** or *minims**. The next few generations will get progressively larger until full-size workers are produced. These minims, although smaller, perform all the tasks of worker ants.

Once they mature, minims immediately begin working—foraging for food, enlarging the nest, feeding the queen, and taking over the job of brood care—so the queen can spend all her energies laying more eggs. They are generally timid in behavior, which is a good survival trait: they are so small and few in number that an encounter with a small but full-sized foraging party could destroy them.

In the ergonomic stage, competition within the colony is at a minimum. The "purpose" or main goal of this stage is to grow as a colony as quickly and safely as possible. The queen does

nothing but eat and lay eggs, increasing the number of ants in the colony. The growth is aided by division of labor—the right amount of foragers to harvest the surrounding area, the right number of nurses to take care of eggs and larvae, and a sufficient number of defenders protecting the colony.

The queen only lays two different types of eggs, female and male, which are fertilized and unfertilized, respectively. During the ergonomic stage, she only lays fertilized eggs, which become female. All female eggs are identical when laid. Whether they mature into workers, soldiers, or new queens depends on the care and feeding the workers provide them as they mature from egg to larvae to pupae to adults. The workers control the ratios of the various types and castes of ants within the colony, and the workers themselves are controlled by the chemical signals that rule ant life. This is covered in detail in the section Social Homeostasis.

THE REPRODUCTIVE STAGE

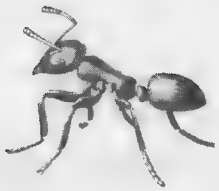
At some point, depending on the species, the colony will begin to produce males and fertile females and enter the reproductive stage. Within any given species, the frequency and amount of reproductives increases with colony size.

Simultaneously, the queen will begin to lay some unfertilized eggs that will mature into males, and the workers that care for the brood begin to groom some female eggs to mature into new queens. Once the males and fertile females mature, it is time for the nuptial flight, and the colony life cycle begins again.

COLONY MOVEMENTS

Ant colonies are not necessarily permanent. Some colonies will move from place to place.

Ants that build huge, deep, secure, complex nests may stay there for many years. Some ants shift their site yearly. Some ants have multiple nests, only one of which is occupied at a time, and will move the brood to another nest if enemies are detected nearby.



There are a number of reasons why an ant colony might move, including physical disturbance, flooding, microclimate* changes, predation, competition, or lack of food. When a nest is attacked by enemies, including other ants, a panic alarm is set off, and workers will incite nestmates to flee. A mechanical disturbance of the nest admitting light and air currents to the brood chambers causes an immediate retreat by the queen and nurse workers. Small changes in the environment, including temperature changes caused by vegetation growing to shade the colony, can cause a migration. If a nest is flooded, ants may need to move to drier ground. Some ants will move to distance themselves from competing species of ants or other nests of the same species. If local food sources are low, an ant colony might relocate to a new location.

SUBCOLONIES AND BUDDING

Many ant species expand their foraging domain by dividing into subcolonies that disperse to new nest sites, and maintain contact through an exchange of foraging workers, eggs and larvae. This is a method of resource distribution of the different types of workers and immatures to fill the needs of the overall multi-nest colony.

Colonies can also bud: split into two independent colonies. This is when a group of workers leaves the main nest along with one or more inseminated queens and makes a new nest that grows into an independent colony, with little or no contact with the old nest. Budding is always found in species where queens are wingless, and sometimes in species with winged queens.

SimAnt

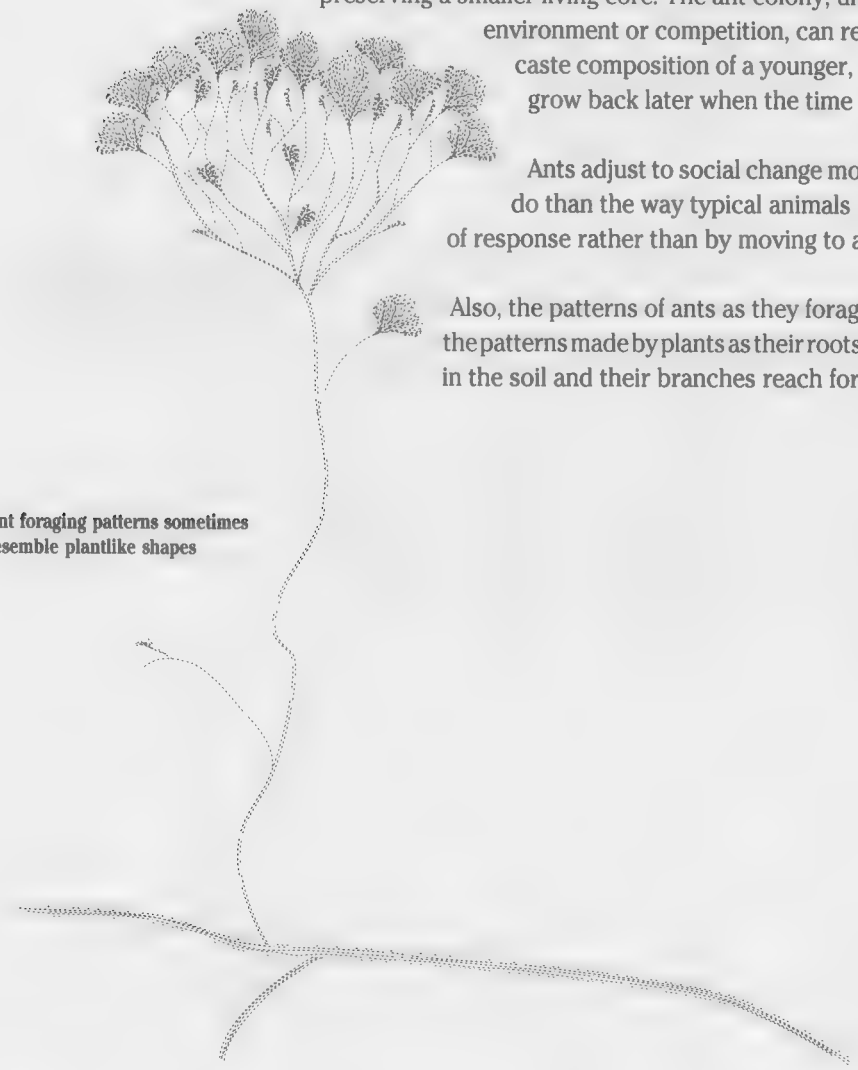
ANTS AS PLANTS

In a number of ways, the typical ant colony resembles a plant. Like a plant, the colony is "rooted" to one nesting site.

Also like a plant, the colony's size is not directly determined by age. A plant, under stress, can go dormant or even allow much of itself to die, preserving a smaller living core. The ant colony, under stress from the environment or competition, can revert to the size and caste composition of a younger, smaller colony, and grow back later when the time is right.

Ants adjust to social change more in the way plants do than the way typical animals adjust: by flexibility of response rather than by moving to a new location.

Also, the patterns of ants as they forage for food resemble the patterns made by plants as their roots search for nutrients in the soil and their branches reach for sunlight.



Ant foraging patterns sometimes resemble plantlike shapes

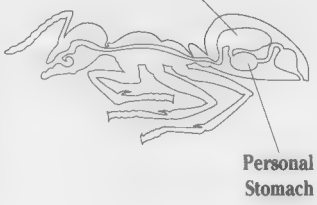
FOOD

As a group, ants eat just about anything. But individually, many ant species specialize in the food they eat. Some ants eat only eggs of other insects, some eat only other kinds of ants. Some ants "herd" aphids and "milk" them for food, some live on tree sap. Some ants eat only seeds, and some ants eat nothing but fungus they grow underground.

As stated earlier in the Basic Anatomy section, ants don't actually eat; they drink. They chew up their food, squeeze the juices out, swallow the juice and spit out the fibre.

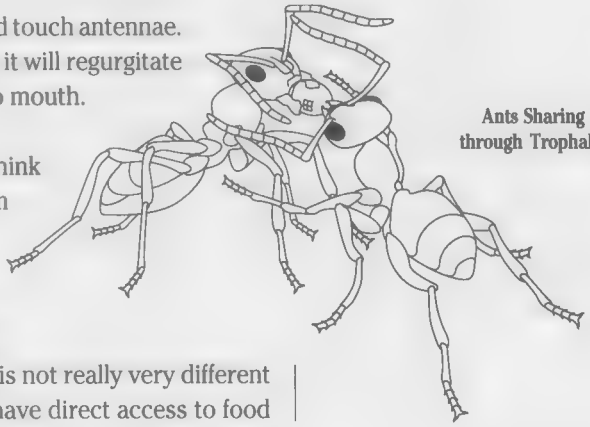
TROPHALLAXIS

Trophallaxis* is a method of sharing food, practiced by all ants, especially among the most advanced species. The more advanced the species of ant, the more they depend on trophallaxis. In more primitive species, more of the ants, even the larvae, feed directly on food (especially insect parts) brought into the nest.



Each ant has a crop, which is a "group stomach." As ants forage for food, they eat, and fill the crop. Only the amount of food needed by the individual ant to survive is released from the crop into the ant's intestine for digestion. The rest is part of the colony food supply, and is distributed from ant to ant. Not all ants go searching for food. The queen, the workers that tend the queen, the larvae, their nurses, and many others need to be fed by other ants through trophallaxis.

Whenever ants meet, they face each other, and touch antennae. If one of the ants has food to spare in its crop, it will regurgitate a drop, and pass it to the other ant, mouth to mouth.



Ants Sharing Food through Trophallaxis

Trophallaxis is easiest to understand if you think of the ant colony as one whole superorganism and the ants as individual cells. The crop is the superorganism's stomach that just happens to be divided up into many small, mobile sections, that travel around distributing food wherever it is needed. This is not really very different from the human body, where all cells don't have direct access to food

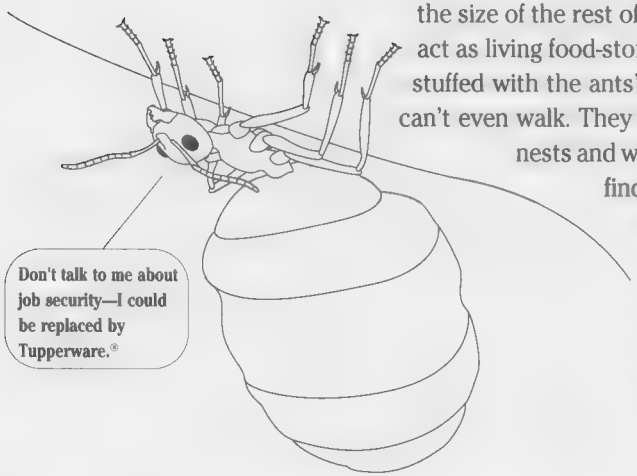
and need to be fed by other cells. The muscles in your arms, for example, do not wander over to your stomach and grab a bite of lunch. The cells in your arm muscles are fed by other cells (the blood cells), which transport nutrients from the stomach throughout the whole body.

TROPHALLAXIS FUNNIES

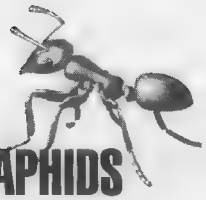
Trophallaxis is very effective. The food is shared and spread around the colony very quickly. In an experiment, a few ants from one colony were fed some honey containing radioactive iodide. Within thirty hours, the radioactive substance had been spread to every ant in the colony.

Trophallaxis, in addition to feeding the colony, is one of the main methods of colony communication and regulation. Each ant that passes the food on adds its own chemical messengers to it. Since it is passed around so quickly, the whole colony will be kept up to date on important colony business within hours, or at most, days. Messages that are transmitted through trophallaxis include: presence or absence of the queen, status of the larvae, lack of food, the presence of intruders, and much more.

In some species of ants, especially those found in dry, desertlike parts of the world, some of the ants have crops that can stretch to many times the size of the rest of the ant. These ants are called repletes*, and act as living food-storage vats. When food is plentiful, repletes are stuffed with the ants' liquid food until they are so large that they can't even walk. They hang from the ceilings of their underground nests and wait. Later, during times when food is harder to find, the other ants come to the repletes and are fed through trophallaxis.



The liquid food in the replete's crop is very sweet, like honey. Some Indians in the American Southwest consider them a delicacy and eat them like candy.



APHIDS

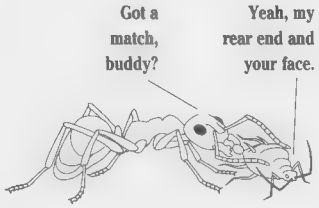
Aphids are insects that attach themselves to plants and suck sap. They tend to suck more than they need, and the extra sap, often referred to as "honeydew," is squirted out their rear ends. This sap attracts bees, who gather it, and it will also grow fungus and mold, which can harm the plant.

Ants also gather the sap for food. Some ants will even "milk" the aphids and collect the honeydew directly from them. In return for the honeydew, ants keep the plants clean of the squirts so no mold grows to harm the plants. They also protect the aphids from other insects, especially ladybugs, and from aphid-eating spiders. They will also remove and eat caterpillars that compete with the aphids for food.

An Ant "Milking" an Aphid

Ants also help preserve both the plant and the herd of aphids by controlling the aphid population—enough aphids will kill the plant. When there are too many aphids, the ants will eat their eggs, larvae and pupae.

Ants aren't smart enough to recognize an aphid and think, "Eureka! A source of food!" They are actually fooled into harvesting the honeydew from the aphids. Over the last few million years aphids have evolved so that their hindquarters resemble an ant's head. As mentioned before, ants constantly face each other, touch antennae, and share food. When an ant sees an aphid's rear end, it thinks it's another ant, and goes up to it and tries to communicate. The aphid doesn't respond like an ant, but it does squirt food in the ant's face. After a while the ant realizes that the aphid's rear end isn't another ant, but it is a good source of food.



OTHER INSECTS AND ARTHROPODS

Ants are one of the primary predators of insects and other arthropods, including ants themselves. A favorite food of many ants is the termite. Their soft white bodies are easy to chew. Termites are sometimes called white ants, but they aren't ants. Just ant food.

Because they eat so many insects, ants are an important part of insect population control. They keep down the numbers of harmful "pest" insects that bother humans and other animals, as well as the insects that harm plants. As far back as a thousand years ago, ants were used by humans in China and Arabia as a biological pest control to protect fruit trees. There is research being done now to see how ants can best be used to protect whole forests from insect pests.

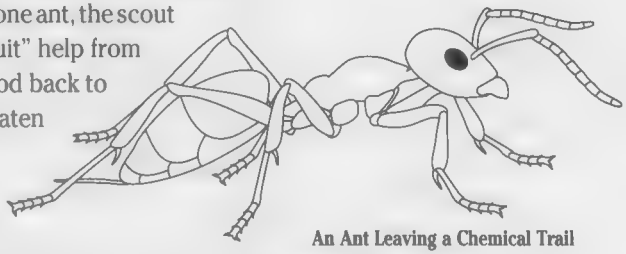
PLANTS

Ants rarely eat plants. They do drink the sweet sap from many plants. Some ants gather leaves, chew them up, spit them out, and grow underground gardens of fungus on them. They only eat the fungus, not the leaves.

FORAGING

The dictionary has a number of definitions for "forage" and "foraging" that range from casually grazing and browsing for food to ravaging, raiding and stripping the countryside. Ants, with their wide range of behaviors, find food by every method defined in the dictionary. For the purposes of this chapter, we'll define foraging as the search and retrieval of food while avoiding or defeating enemies. An integral part of foraging behavior in ants establishes their territory and sets up a living warning system around the colony.

The basic pattern of foraging among ants consists of scouts (usually older workers) looking for food. When they find food, if they can carry it all back alone, they do. If there is more food than they can carry in one trip, they leave a chemical trail from the food to the nest that other ants can follow. If the food is too large to be carried by one ant, the scout will return to the nest, leaving a trail, and "recruit" help from other ants that will help cut up and carry the food back to the nest. All the while, the foraging ants can be eaten or attacked by birds, spiders, other arthropods, or other ants.



An Ant Leaving a Chemical Trail

FORAGING THEORY

Foraging theory is an attempt to explain and model foraging behaviors and their evolution. It applies to all organisms, but will be covered here primarily as it relates to ants. This modeling system looks at foraging as an economy based on energy, where the organism being modeled seeks to maximize its energy gain vs. energy expenditure.

When applied to social insects, this economy of energy can be described by the following rules:

- The biomass* and biomass growth of the colony can be translated to energy units;
- Foraging success, brood care, and other nurturing activities are considered energy gained;
- Protective activities, such as nest building and defense, reduce mortality of individuals and are considered energy saved;

Metabolism and death of individuals are considered energy loss. (Deaths of individual foraging ants are not a big deal, energy-wise. These foragers are nonreproductives, so they don't endanger future brood by dying, and are considered expendable energy units.)

Foraging theory reasons that organisms, through evolution by natural selection, modify their behavior in four basic ways to increase their energy efficiency:

(1) choice of food (optimum diet),
(2) choice of food patch (optimum location),
(3) allocation of time invested in various food patches (optimum time budget),
(4) regulation of foraging patterns and speed of movement.

Foraging patterns are the paths that organisms follow as they search for food and return to their home or nest (if they have one). In the case of ants and other animals with permanent nests, foraging patterns can be looked at as a series of sallies from a central location.

Foraging patterns are constrained by two forces, one external to the organism, one internal. The external constraint is death of organisms, due to accidents, getting lost, or attacks from predators or competitors. Many ant workers are lost or killed while foraging. Ants can react to change their foraging patterns away from places where they experience great loss of life (energy).

The internal constraints are the limitations of the organism itself: the senses, strength, and brainpower. Because of these limitations, the organism can only travel so far, kill or carry home certain-sized prey, and solve a certain level of problem that it confronts while foraging.

FORAGING STRATEGIES

Ants display a great variety of foraging strategies (methods of finding and retrieving food). Foraging behavior has been studied and divided into three major categories of behavior: hunting, retrieving, and defense.

There are three kinds of hunting behavior:
(1) by solitary workers;
(2) by solitary workers following other trunk trails*; and
(3) by groups of workers.

There are four kinds of retrieving behavior:
(1) by solitary workers who return home on their own;
(2) by individual workers who return home by following trunk trails;
(3) by individual workers recruited to the food site by scouts; and
(4) by groups of workers who work together to carry large food items.

There are four kinds of defense behavior:
(1) guard workers during hunting;
(2) no guard workers during hunting;
(3) guard workers during harvesting and retrieval of food; and
(4) no guard workers during harvesting and retrieval of food.

By combining the above kinds of behaviors, one from each category, there are 48 possible three-state foraging strategies that ant colonies can use. Most species, depending on the situation, will use two or more of the three-state strategies. For instance, in many species, when food is found, if the ant that found it can carry it alone, it will bring it back to the nest unaided (retrieving #1), but if it finds food that is too large to carry, it may recruit help (retrieving #4).

TIME AND TEMPERATURE

Ants only forage during certain times of the day, depending on the species and the climate. "Herds" of aphids are sometimes shared by two species of ants: one that harvests during the day, the other at night.

Ants only forage during certain ranges of temperature and humidity. Some species of ant can forage in temperatures as low as 0 degrees C (32 degrees F), and others as high as 67 degrees C (152 degrees F), but most species only forage over a 20–30 degree temperature range. Higher relative humidity allows ants to tolerate higher temperatures, but rain will stop foraging altogether.

NAVIGATION

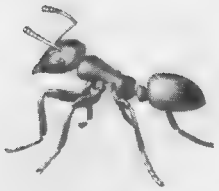
An important part of foraging is heading in the right direction to find food, and not wandering in circles. Equally important is finding the way back home with the food.

Ants establish and follow main tracks or paths to and from known food sources. They mark these tracks with the colony's smell so any ant can follow it. When these tracks are used long enough, they are like multi-lane highways for ants. When ants are lost, and they come across one of these tracks, they can follow the smell in either direction and either find food or the nest.

When exploring for or returning with new food sources, navigation is more difficult. It requires vision, memory, and the use of the sun as a compass.

Ants can see and remember landmarks along the way as they forage, and can turn around and follow them back home. They also navigate by the sun. Ants remember the location of the sun as they head out, and can turn around so the sun shines from the opposite direction to find their way back. Sun-compass navigation is based on the ants' use of their compound eyes, and their exceptional memory (for an insect). Ants can sense into which of the many facets of their eyes the sun shines, indicating the direction of the sun. As they travel, and walk around rocks and plants, the facets that are lit by the sun change. Ants remember the pattern of lit facets, and can remember them in reverse when it is time to go home. Ants that forage at night can use the moon as their compass. Sun-compass navigation is also a time-saver. When ants forage long distances for new food sources, they wind and loop their way through the environment, but once they find food, they head home on a very direct path that they find through the position of the sun.

The process of sun-compass navigation is complicated by two things: the sun's position in the sky changes during the day, and the sun's movement in the sky changes every day depending on the season. Ants are not smart enough to understand astronomy, but they instinctually make the necessary allowances for time and seasons in their navigation.



It must have taken a long time for ants to evolve this ability, but they've been around for a long time.

In species of ants that live in trees, a three-dimensional area must be navigated. These ants have sensitive hairs on their neck, petiole, antennae, and gaster. As ants change positions, to move up an incline or down a slope, their bodies bend and the hairs move. The ant remembers the direction and degree of the hairs' movement, and uses this information as an up-and-down gauge while navigating.

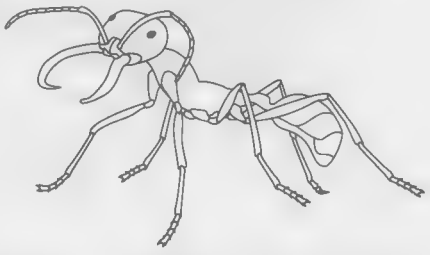
SOLITARY FORAGERS

Some species of ants only forage individually. These ants forage over a roughly circular area surrounding their nest, and can make 5–10 forays each day, over a period of 2–3 hours. The forager will come out of the nest and head off in more or less a straight line, find food, bring it back to the nest, then leave again, in approximately the same direction. The ant will continue to head in this same direction for at least two weeks, and will only head in one or a very few directions over its lifetime, at least in part because it doesn't live very long.

Foragers lead a very risky life. They are eaten by birds, spiders or other insects. In some parts of the world, solitary foragers have an active foraging life expectancy of as low as 6.1 days, but still manage to collect 15–20 times their body weight in food during this time.

GROUP FORAGERS (ARMY ANTS)

At the opposite end of the foraging behavior spectrum are the army ants of South America and the driver ants of Africa. In these species of ants, whole colonies forage together. These ants don't have permanent nests. They travel in masses of millions of ants, and like a living stream of hungry little mouths, eat almost any living thing in their path. They don't have a nest to return to with their food; they make camp each night wherever they are by forming their bodies into a large ball with the queen and brood at the center.



SPECIAL FORAGING TECHNIQUES

While there are numerous techniques employed by ants as they gather their food, a few stand out as being very productive and advantageous to the success and survival of ant colonies.

GROUP RETRIEVAL

Group retrieval is when two or more workers cooperate in bringing home a piece of food that one can cannot handle alone. Ants have evolved very involved and highly efficient ways of working together to move heavy loads, and in some species can move 10 times more weight per ant in a group than they can individually (with only a loss of about 50% of their travelling speed).

ROTATION OF FORAGING DIRECTION

Group foraging species, such as army ants, travel in a straight line for a while, then stay in one place for a few weeks. Even while stationary, they send out daily raids for food. Each day, the direction the foragers travel shifts by an average of 126 degrees. This increases the ants' harvesting efficiency by keeping the ants from eating all the food near their "campsite" at once. The pattern they follow resembles the spiral leaf arrangement used by many plant species to minimize self-shading.

OUTPOSTS

Another method of improving foraging efficiency is setting up outposts a distance from the nest. Workers stay at the outposts for a while and forage for food from there. Once a lot of food is gathered, it is transported to the nest. Sometimes larvae are carried to the outposts and kept and fed there to reduce the amount of food that has to be carried.

OFFENSE AND DEFENSE BY FORAGERS

Ants have to stay alive long enough to find food, and return it home safely. And once the food is in the nest, the ants still may have to defend it and themselves. To this end, ants have developed a number of offensive and defensive weapons and tactics.

ARMOR — all ants have exoskeletons, but some have developed very thick and strong protective coverings.

SOLDIER CASTES — the soldiers, or major workers, of some species can be formidable foes in battle. They are often large (for an ant), and have large heads, cutting or crushing mandibles, stings, and enlarged poison glands. Soldiers defend nests and foraging workers.

GROUP ATTACKS — in the same way that ants work together to carry food, they work together to kill enemies.

TRAP MANDIBLES — some ants have long mandibles with sharp teeth at the ends that convulsively open and snap shut during battle.

SABER- AND HATCHET-SHAPED MANDIBLES — some ants have strong, sharp mandibles that are efficient at piercing exoskeletons or chopping off appendages.

CRYPTIC COLORATION — some ants blend into the scenery, making them hard to find. Some ants have hairs that hold pieces of dirt that act as camouflage.

PLAYING DEAD — some ants will play dead when threatened. Since many of their enemies, including other ants, have compound eyes that only sense motion, this is a very effective technique.

SPINES — some ants have sharp, pointed spines that discourage or punish attackers.

ANTENNAL SCROBES — some ants have scrobes, or grooves, in their heads into which they can fold their antennae for protection during battle.

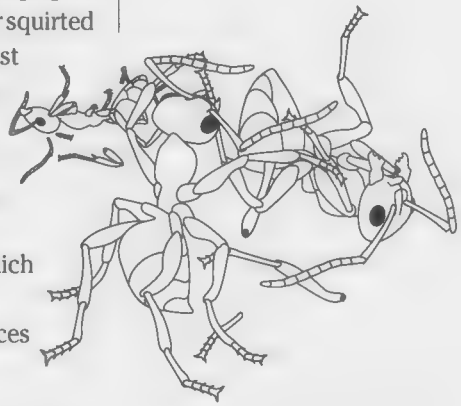
VENOMOUS STINGS — the more primitive ants have stingers that can pierce enemies and inject poisons.

POISON DROPLETS AND SECRETIONS — all ants have, to some degree, the ability to produce poisons and secretions that are damaging or repellant to enemies. These chemicals are sometimes sprayed or squirted at targets, sometimes rubbed on enemies and sometimes just produced and allowed to evaporate, the fumes repelling attackers.

PROPAGANDA PHEROMONES — slavemaking species can produce pheromones that fool other ants into thinking that they are harmless.

WARNING COLORATION — some ants are brightly colored, which seems to scare away some predators.

PHRAGMOSIS — some soldiers use their heads to block entrances to nests.



REVERSE PHRAGMOSIS — some ants block nest entrances with their gasters, often with poison drops on their ends.
EVASIVE ACTION — some ants jump or bounce to distract enemies. Some ants will jump from trees or bushes to escape enemies. Many ants hide under leaves or other debris.
CLOSING NEST ENTRANCE — many species block nest entrances with soil at night, or when attacked.
COVERING TRAILS AND FOOD SITES — some ants will cover food or trails to food with soil to protect foragers from predators and to protect the food from competitors.

TERRITORIALITY

One of the best ways to protect a food source is to keep competitors out of the area.

Territorial strategies in ants depend on the species' food source, the distribution of the food, and the competition. Some ants protect the area surrounding their nest absolutely, killing any ant from another colony—whether it is the same or a different species—in a radius around the nest. This is most common in areas where food is widely and evenly distributed. Other ants, in areas where food is less evenly distributed, only protect actual foraging areas and the trunk lines, or paths, to and from these areas. And yet other ants, whose food is very patchily distributed, only protect the actual areas presently being foraged.

COMMUNICATION

As with any society, an ant colony requires communication between its members for its continued existence. Communication among ants is not as detailed as communication between humans, but is more than sufficient to ensure their survival. Signals are passed through a series of tappings, strokings, stridulations*, graspings, bumpings, nudgings, antenna touchings, and tastings, but primarily and above all, by chemicals.

CHEMICAL COMMUNICATION

Ants are very much controlled by chemicals. They are very sensitive to them, and "smell" them with their antennae, as well as "taste" them with their mouths.

TERMINOLOGY

The following terms will provide a little background for understanding chemical communication among ants.

Semiochemicals* are any substances used in communication, whether between species or between members of the same species.

Allomones* are semiochemicals used to communicate across species.

Pheromones* are semiochemicals, usually secretions from glands, used to communicate within the species, and are the primary chemicals in ant communication.

Releaser effects*, caused by releaser pheromones, create stimulus-response reactions in the receiver's nervous system.

Primer effects*, caused by primer pheromones, actually alter the receiver's body, especially the endocrine and reproductive systems.

CHEMICAL SOURCES

The pheromones that ants use in communication are made in their many *exocrine glands**. At least 10 separate glands have been found to be used for creating communication chemicals. Different species of ants, depending on their primitive or advanced state, may have different glands that serve this purpose, but all ants have some glands that produce these chemicals.

There are six key exocrine glands that occur in most ant species:

DUFOUR'S GLAND — typically a small gland, the Dufour's gland is located in the gaster, very near the sting. Depending on the species, the Dufour's gland can produce a wide variety of chemical compounds, at least some of which play a part in communicating alarm, recruitment, and sexual attraction.

POISON GLAND — poison glands are located in the gaster. The primary purpose of this gland is to produce either formic acid or some other venom (depending on the species), which is stored in the poison sac until it is needed for defense or paralyzing prey.

PYGIDIAL GLAND — this gland also produces toxic substances, and in many species enhances or partly replaces the function of the poison gland. In addition, the pygidial glands of some species produce pheromones that send alarm signals. In other species, this gland contributes chemicals for recruitment, sexual attraction, and marking trails.

STERNAL GLANDS — Sternal gland is actually a generic term that can refer to a number of different glands in the sternum, or lower portion of the ant. There are many different types of sternal glands in various species of ants. These glands are often the source of trail pheromones (trail-marking chemicals) and recruitment chemicals.

MANDIBULAR GLANDS — located in the heads of most ants, these glands make chemicals used in defense and in alarm communication. They empty through the mouth, near the mandibles.

METAPLEURAL GLANDS — Located on both sides of the thorax, the metapleural glands produce chemicals that are stored in reservoirs and released from the ants' sides. There is still some dispute about the purpose of this gland. Some believe it produces pheromones for recognition and identification of nestmates. Some believe it serves no purpose in communication at all, but manufactures antibiotics that protect the ant and nest from microorganisms.

CHEMICAL COMMUNICATION EFFICIENCY AND RECEPTION

Pheromones and chemical communication in general are very efficient. It takes much less energy to produce a few molecules and expel them into the air than to walk around explaining the existence of danger to hundreds of individuals.

The chief disadvantage of chemical communication is the long time it takes the message to fade out. Ants can't send a stream of different messages quickly. They have to wait for the first signal to evaporate or be blown away by the wind before the next one can be understood.

Ants' response to pheromones can sometimes change depending on proximity to the source and concentration of the chemical. At a distance, or a low concentration, one pheromone may provoke interest in an ant, causing it to approach the source. When the ant gets closer to a higher concentration, it may be stimulated to full panic mode.

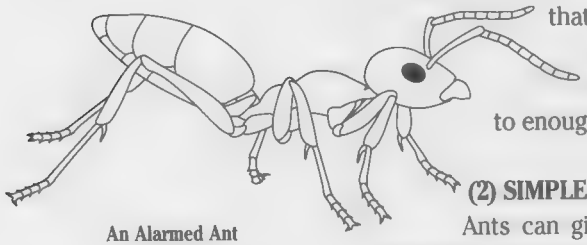
Since these communication chemicals are produced in minute amounts, the receptors have to be very sensitive. Ants' antennae are sensitive enough to "smell" the tiniest amounts of pheromones. Ants even smell in stereo, and can tell the direction of a chemical source. They can tell if one antenna is receiving more of the chemical than the other, and know that the source is in the direction of the stronger smell. Ants use this method to follow trails.

COMMUNICATION AND RESPONSES

Researchers have recognized 12 categories of communication and responses:

(1) ALARM

When an ant is attacked or recognizes danger, it can send an alarm signal that alerts nearby ants of danger. This signal is chemical in nature, and is not detailed. It causes other ants to emit the same pheromone, and when exposed to enough of it, they get excited into a battle frenzy.



An Alarmed Ant

(2) SIMPLE ATTRACTION

Ants can give off chemical signals that other ants will be attracted to, and follow, such as trails to food. When a worker finds food, it returns to the nest slowly, rubbing its gaster on the ground to leave a scent trail to food. Other ants follow this trail, and when bringing back food to the colony, they also leave the return trail, which increases the odor and the attraction for more ants to follow to the food. When the food is gone, the ants return without leaving a scent trail, and eventually the odor will fade and ants won't follow it.

(3) RECRUITMENT

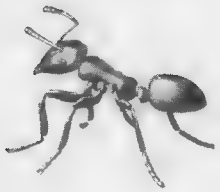
When ants find a large food source or discern the need to move to a new nest site, they must recruit other ants to help. This is done through a combination of chemical signals and physical activity that ranges from running around excitedly to bumping and nudging other ants to actually picking up other ants and carrying them.

(4) GROOMING

Ants clean themselves and each other constantly. Ants emit attractant chemicals to their body surfaces causing other ants to lick and groom them. Larvae emit chemicals that attract nurse ants to assist them at molting.

(5) TROPHALLAXIS

Trophallaxis, the exchange of oral and anal liquid, is induced by both chemical and physical means. Not only is it a primary method of food



distribution among ants, it is also a primary method of communication. As food is exchanged between workers and workers, workers and queens, and workers and larvae, the chemicals emitted by each ant are added to the food and spread throughout the colony. In this way the queen is kept informed of the status of the brood, and the workers are kept informed of the status of the queen.

(6) EXCHANGE OF SOLID FOOD PARTICLES

Ants also exchange particles of solid food. Requesting the food is a combination of chemical and physical signals.

(7) GROUP EFFECT

Ants can chemically facilitate or inhibit a number of activities among other ants.

(8) RECOGNITION

Ants need to recognize other ants: whether or not they are the same species; whether or not they are nestmates; whether or not they are injured or dead. This recognition is all through the sense of smell: each colony has its own distinct odor that members of the colony can recognize.

(9) CASTE DETERMINATION

Ants can also "smell" what caste their nestmates are. Workers are attracted to the queen's odor, so they groom and feed her. Workers also need to discern other workers or soldiers so they can recruit help from the proper sources.

(10) CONTROL OF COMPETING REPRODUCTIVES

Workers will physically control reproductives until the time is right for the mating flight.

(11) TERRITORIAL AND HOME RANGE SIGNALS AND NEST MARKERS

Ants mark their nests, territory and trails with their distinct colony odor. This helps ants find food and find their home, while discouraging enemies from trespassing. Ants will instinctively defend areas that have been marked with their colony odor.

(12) SEXUAL COMMUNICATION

Ants, through a combination of visual and chemical signals, communicate the necessary information to propagate. Ants must recognize in sexual partners the right species and the right sex. They also must assess potential mates during sexual competition and finally, synchronize their sexual activity.

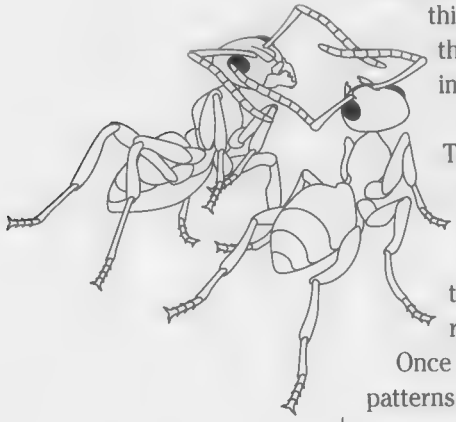
ACOUSTICAL COMMUNICATION

Some species of ants use vibrations to communicate. They do this in two ways. One, by banging, rapping, or drumming their bodies against the soil or nest wall, and two, by stridulation—scraping one part of their bodies against another. These acoustical signals are believed to be used in signaling alarm, recruitment, and termination of mating by females, and to enhance chemical messages.

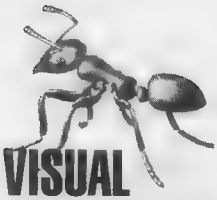
TACTILE COMMUNICATION

Ants constantly touch and feel each other with their antennae and their forelegs. At least some of this activity involves communication.

When ants meet, they often touch antennae to antennae or antennae to body, and move them in very complex patterns. It was once thought that this contact conveyed a lot of information, but now it is believed that the antennae touching is more for the purpose of receiving information—sniffing nestmates—than sending it.



The best-understood tactile communication among ants is used when inducing trophallaxis. One ant will get another ants' attention by tapping its body lightly with antennae or forelegs. This communicates the equivalent of, "Hey, you!" and the tapped ant faces the tapper. Next, the first ant will lightly and repeatedly tap the other ant's labium until it regurgitates food. Once the food is flowing, both ants move their antennae in complex patterns that as far as we know have no meaning whatsoever.



VISUAL COMMUNICATION

Whether or not ants use visual signals to communicate is not yet established. Some believe that ants will jump around excitedly or move quickly to signal other ants to follow them, and that the other ants get the message solely by seeing the movement. There is no real proof that this is true. There may be chemicals involved in the process and the motion may be unrelated to communication.

PROPAGANDA

Some species of ants use chemical propaganda. They produce chemicals that fool or confuse their enemies. These chemicals can cause the victims to either think that the enemy is a friend, or make them panic and attack their own nestmates. In either case, the victims become easier to conquer.

BEHAVIOR

The most fascinating thing about ants is their behavior. It has been studied and pondered by scientists and children alike all over the world.

EMERGENT BEHAVIOR

In ants, very simple behavior as individuals produces complex behavior as a group.

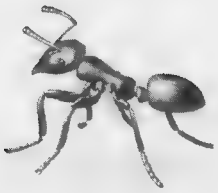
Individual ants, depending on the species, can only perform between 20 and 40 distinct acts, yet the hundreds, thousands, or even millions of individual ants doing 20 to 40 things results in very complex, successful, adaptive behavior.

This emergent behavior of many interacting simple acts combining to create complex behavior is of interest not only to myrmecologists and entomologists, but to many areas of science. It is this emergent behavior that has made ants the "mascots" of the artificial life movement in computer science. Emergent behavior is the basis of SimCity, the successful computer game where the individual citizens have a number of simple behaviors that combine into a complex realistic simulation of human behavior at a city level of organization.

SOCIAL HOMEOSTASIS

Any society or complex organism is composed of many individual parts that must work together for its survival. There is a "steady state" that must be maintained, where all the parts or individuals are in sync, and working for their common good.

In a human body, the brain, hands, heart, digestive system, and lungs must work together to obtain and distribute food and oxygen throughout the body or the body dies. In a human society, the farmers, transportation workers, marketers, and cooks must maintain the flow of food from its growth to its final destination, or the society crumbles. In an ant society, the foragers must bring back the proper food and distribute it to other ants who in turn feed other ants, including the queen and the brood. If there is a breakdown along the line, the colony dies.



This steady state is constantly threatened by outside influences such as lack of food, enemies, and weather, and internal influences like population density.

The steady state must be maintained internally through feedback responses. This process of self-regulating is called homeostasis*. Social Homeostasis* is the maintenance of steady states at the level of the society either by control of the nest microclimate or by the regulation of the population density, behavior, and physiology of the group members as a whole.

The basis for this self-regulation is the organism's or society's organization.

ORGANIZATION AND HIERARCHY

Human and ant organizations are very different. In a human organization, for example an army or a business, there is one leader or boss, who communicates with a few subordinates, who in turn communicate with their subordinates, and so on down the line to the soldiers or workers at the bottom. Information in the form of commands flows in one direction, from top to bottom. The workers at the bottom and leader at the top never directly communicate. And the lowest level cannot directly influence the highest level's behavior.

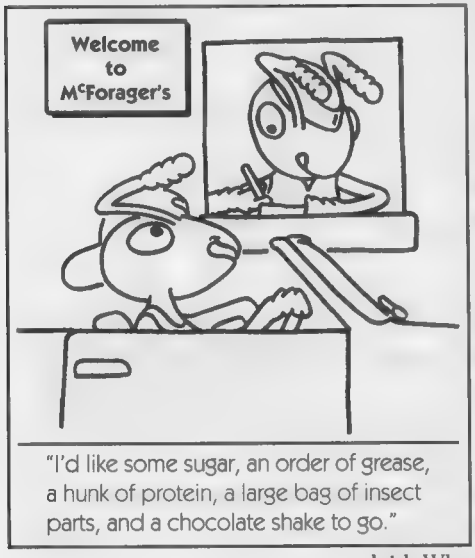
In an ant colony there is no chain of command. Groups of workers, as castes, specialize in different tasks, but each individual ant is likely to communicate with any other ant. All ants are open at all times to having their behavior influenced by almost any other ant in the colony.

Unlike the human organization where the highest level is one individual, the highest level of an ant colony is the total colony. An advantage of this type of organization is that parts of the colony can react quickly and locally to an emergency. An enemy can be attacked or a larva fed without a series of messages and commands going up and down the levels of command.

EXAMPLES OF SELF-REGULATION

Different members of an ant colony require different types of food. For example, among fire ants, the older workers (foragers) mostly require sugars, young workers require sugars and fats, larvae require fats and proteins, and egg-laying queens require a lot of protein. In order to properly feed the colony, the foragers must know what type of food is needed when and in what quantity.

FUN WITH FORAGING

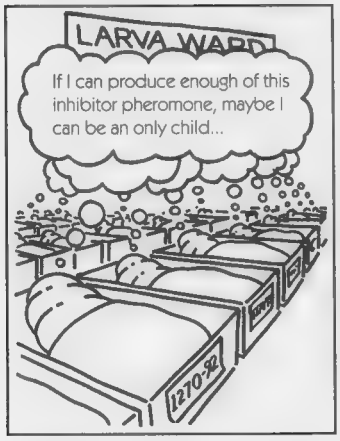


"I'd like some sugar, an order of grease, a hunk of protein, a large bag of insect parts, and a chocolate shake to go."

The foragers don't walk around the colonies taking orders: a feedback system exists between the foragers and the final users of the food. The foragers first bring back any kind of food they can find. Then they distribute it to whoever wants it. As long as they can unload their food quickly, they will keep bringing back the same thing. When it starts taking longer to unload the food they bring, they start looking for a different kind of food. In this way the individual foragers get feedback from the whole colony on the type of food required, which changes the behavior of the foragers as a group.

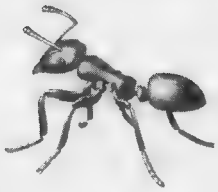
An important self-regulating activity in an ant colony is the rate of egg laying. There is an optimum number of eggs to be laid. When too many or too few eggs are produced, energy is wasted. Either the eggs hatch into larvae that can't be fed, or the colony growth cycle is slowed.

LARVA LAFFS



The egg-laying regulation is based on a feedback loop between the queen and the larvae, with the nurses passing the information back and forth. The larvae emit pheromones depending on their stage of development. The nurses lick and groom the larvae as well as feed them, and absorb some of this pheromone. As the nurses feed the queen, she in turn receives some of the larvae pheromone. The quantity and type of pheromone received by the queen directly affects her rate of egg-laying. In particular, when the larvae reach the fourth instar and near maturity, the pheromone they produce increases the queen's egg production.

Self-regulation is also involved in caste control (the relative numbers of major and minor workers), reproduction (producing fertile females and



males), recruitment and trail-laying, as well as most other aspects of colony life.

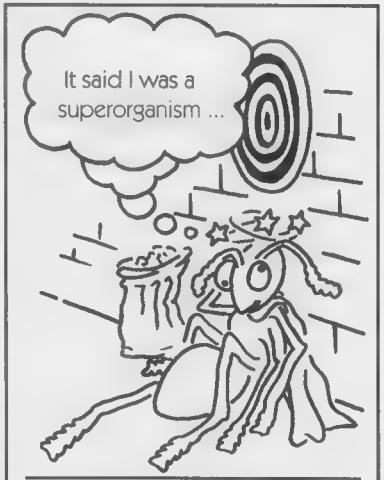
THE SUPERORGANISM

A theory that has come into, out of, and back into prominence is the idea of looking at an ant colony as a single organism, with the individual ants as cells.

When thinking of the colony as one organism, the loss of individual ants is very minor, like a human trimming a fingernail. In this view:

The amount of ants in the colony relates to the growth of the organism.
Trophallaxis (the exchange of liquid food among colony members) replaces the circulatory system.
The caste system, with different types of ants performing different duties for the colony, compares with the differentiation of cells into different tissues and organs of single organisms.
The queens, fertile females and males are the colony's sexual organs.
There is even a co-relation between the organizational processes of workers in a colony and neurons in a human brain, which has been pointed out and written about by Hofstadter and Minsky (see Part Three).

DUMB ANTS



An ant who just reads headlines in ant books.

The qualities of an ant colony that qualify it as a superorganism are:
(1) It behaves as a unit.
(2) It shows some idiosyncrasies in behavior, size, and structure that are peculiar to the species, and other idiosyncrasies that distinguish it from other colonies of the same species.
(3) It has an adaptive cycle of growth and reproduction.
(4) It is differentiated into "germ plasm" (queens and males) and "soma" (workers).

Also in support of the superorganism theory is the fact that evolutionarily speaking, the colony, not the individual, is the unit of selection. In the process of natural selection, it is the whole colony, not an individual ant, that survives and perpetuates its genes. In many cases, colonies only have one queen, therefore only one set of genes to pass on.

Whether or not an ant colony is "really" a single superorganism, this concept is at least a helpful way to view the colony's activities, emergent behavior, and social organization. It can be used as a framework for future study of ants and social insects.

ADAPTIVE BEHAVIOR

Ant colonies can make adaptive changes in their behavior when necessary. The following examples only apply to some species, and are only a few examples of the many adaptive behaviors that exist.

One example of adaptive behavior is the choice of single or multiple queens within a nest. In areas with limited nesting sites, a colony of ants will allow multiple queens to exist in the nest so the colony can grow. The same colony, when moved to a site where there are many nesting sites, will split up into smaller single-queen nests.

Some ants will adjust the time of day they forage for food, depending on the presence of food, the weather, and the availability of foragers.

Ants will sometimes modify their nests in response to parasites or predators. If they are attacked at an entrance, for example by a spider that built a nest there, they will plug the entrance. They will even try to remove the physical and chemical traces that marked the spot as an entrance by covering it with sand and leaves and grass.

LEARNING

As stated in the Basic Anatomy section, ants don't have the brainpower to solve problems, but, even with their tiny brains, ants are capable of a certain amount of learning and memory.

Many of their responses, even complicated ones like self-grooming and regurgitating, are "hard-wired" into their genes and are purely instinctual. Other responses are basically genetic, but modified in degree by learning.

The simplest form of learning in ants is habituation*, or getting used to something. If you stick a glass rod down an anthill (something that scientists do), they will attack it. If you repeat it again and again every few

minutes, and do no real damage to the nest, the ants will get used to it and react less and less violently.

Ants are also capable of associative learning*. This involves classic conditioning. Ants' behavior can be modified when they associate the new behavior with a reward, such as honey water.

Ants are also subject to imprinting*. Very common in birds, this is where the young animal during its first few days of life becomes "attached" to its mother or whomever or whatever they see, and will follow it around. Birds, especially ducks and geese, have been known to be imprinted by humans. The primary imprint on ants is their colony odor, and occurs during their first few days after eclosion from the pupa. If an ant is isolated from the colony for its first few days as an adult, it will have trouble integrating into the colony.

The most sophisticated learning in ants involves memory and navigation. Ants can learn small mazes only two or three times slower than laboratory rats (which have much bigger brains). Some ants can remember their way through the maze for up to four days. In their natural environment, some ants can memorize positions of four landmarks and use them for navigating up to a week later. There are some species of ants that can even remember specific locations outside their nest over a winter of hibernation. By using visual landmarks, ants can remember locations of a few places at once and travel between them.

While foraging, ants can learn the position of the sun and use it as a compass for finding their way home. This sun-compass navigation is further complicated by the fact that the sun's position in the sky changes with both the time of day and time of year. Ants can make allowances for movement of the sun, and navigate quite well. The process needed to use the sun as a compass and make the "calculations" to allow for time and season is a combination of instinct and learning.

Ants can be fooled. If you use a mirror and a shade (piece of cardboard) to make the sun seem to shine from the opposite direction, an ant that

is returning home using sun-compass navigation will turn around and go the wrong way.

Ants can also be fooled by changing visual landmarks. Scientists took photos of tree branches, blew them up to poster-size and hung them over a nest. After a while, the ants learned the branch patterns and used them for navigating. When the photographs were turned around, the ants turned around and went the wrong way.

There are still many things that we don't know about ant learning. We don't know if they learn by operant conditioning*, which is a form of associative learning where an animal learns a new behavior by doing it by accident and it "pays off" with reinforcement like food or survival. And we don't know if ant brains partition learning into short-term and long-term learning.

THERMO-REGULATION

Ants are very sensitive to temperature, and can only function properly within certain temperature ranges.

Bees regulate the temperature in their hives by using their wings as fans to increase airflow in the hive, and by gathering water that cools through evaporation. Since most ants don't have wings, and they can't move fast enough to gather water and bring it back, they use other methods of temperature regulation.

In general, various species of ants use combinations of the following five methods:

(1) Correct location of the nest
Many ants make their nests in soil, where only a few inches below the surface the temperature and humidity vary very little all year long. Ants that nest in sandy, desertlike areas make their nests deep in the ground to insulate them from the heat. When shade is available in hot climates, ants will make their nests there to keep cool.

(2) Efficient construction of the nest
In warm areas, ants will cover nests with leaves and humus, making a layer of insulation between the nest and the outside world. Ants often make nests under rocks, which heat up quickly in the sun and warm the earth (and ants) below. Some ants make their homes in large anthills that are constructed to absorb heat from the sun. Other ants build their hills with material that will decay and give off heat in the process.

(3) Migration within the nest
Eggs and larvae, pupae, and adult ants all prefer different temperatures. Daily life within an ant nest consists of ants moving themselves and their brood up and down, from chamber to chamber, all day long to stay at the right temperature.

(4) Migration among multiple nests
Some species maintain more than one nesting site, and when one is too hot or cold, they move to another.

(5) Regulation of metabolic heat
Ants can control temperature within portions of the nest with their body heat. Heat in a chamber increases as the ants bunch together, and decreases as they disperse. In cool weather, some ants will leave the nest and sun themselves, absorbing heat. Then they return to the nest and radiate the heat. When enough ants do this, it can affect the overall temperature of the nest.

HUMIDITY REGULATION

Ants are very sensitive to humidity and will die if they dry out, but the pupae stage of ant development requires a chamber with a drier atmosphere than at other stages of ant life.

There are four basic methods ants use to control humidity within their nests:

(1) Nest construction
Anthills are constructed to hold humidity as well as heat.

(2) Gathering water drops

Some species gather drops of dew or any other water they can find, and bring it back to the nest in their mandibles. They let their nestmates drink some of the water, feed some to the larvae, dampen cocoons, and place the rest on the ground to humidify the nest.

(3) Making water traps

Some species place hygroscopic* objects, like dead ants and bird feathers, near their nest entrances. In the morning, dew forms on these objects, and the ants gather it.

(4) Wallpapering

To keep the humidity down in certain chambers (to suit the development of pupae), some ants wallpaper, or cover the walls of some chambers with multiple layers of discarded cocoons. This wallpaper absorbs moisture, making the air in the chamber drier.

FRIENDS, ENEMIES AND CAMP FOLLOWERS

Ants are a powerful and integral part of the world's ecology. Many other animals and even plants have evolved physically or behaviorally to either defend themselves from or take advantage of ants.

Ants don't survive alone in the environment. They have "friends," animals and plants that provide ants with food and shelter in return for protection. They have "enemies," predators and parasites that eat ants and their brood, or steal their food, and provide little or no return advantage to the ants. And there are "camp followers," which range from insects to birds that follow or travel with ant colonies and neither directly help or harm the ants.

FRIENDS

OTHER INSECTS

Aphids, some caterpillars, and other insects are "milked" by ants. The ants get honeydew from this relationship, and in return protect their "herds" from parasites and predators.

Some insects live in ant nests, and only eat dead ants. They get their food in return for corpse clean-up duty.

OTHER ANTS

Usually, when ants of different species have nests right next to each other or have some connecting underground tunnels, there will be a war. Ants are very territorial and will try to eliminate ant competition for food. In some rare instances, if the two species are diffferent enough in their food supply and foraging behavior, they will tolerate each other—barely. There are no known cases of two species of ant living together to the mutual benefit of both species.

PLANTS

Some plants live in a symbiotic* relationship with ants. The relationships between ants and plants range from mild mutual benefits to complete dependence. Some species of plants will die if their ants are removed: the plants are soon eaten by caterpillars and other insects.

Some plants provide food and homes for ants. These plants usually have hollow places in their stems, thorns or branches where ants live, and often ooze sweet sap that ants can eat. In return, the ants protect the plants from predators, which include anything that eats leaves, from caterpillars to antelope. These plants sometimes have coatings on their seeds that attract ants. The ants take the seeds, eat the coating, and leave the seeds to grow. Plants also use attractants to attract ants to their flowers to aid in pollination.

Ants aid plants in a number of other ways, too. Ants feed plants. They turn and aerate the soil, and enrich it with excrement and refuse. They regulate the local ambient temperature and humidity. Near to an ant nest is an ideal spot for many plants. Some ants inadvertently protect their plant homes from other plants that crowd in too closely. The ants clear away nearby vegetation that touches their homes to prevent invasions of alien ants that attack from other plants. By clearing out all vegetation within a certain radius, their plant receives more sunlight and more nourishment from the soil.

ENEMIES

OTHER ANTS

Ants are one of the primary predators of ants. Not only will ants attack and kill other species of ants, but they will war with other colonies of the same species.

Besides all-out war, ants have sneakier methods of preying on other ants. Thief ants are very small, and will make nests near the nests of larger ants. They dig tunnels into the larger ants' brood chambers, sneak in, steal eggs and larvae, and run back into the tunnel, which is too small for the larger ants to enter.

Many species of ants are social parasites to other ants. This will be covered later, under Slaver Ants.

OTHER INSECTS AND ARTHROPODS

Ants are so numerous and so successful that they have become, in a sense, an ecosystem. In this ecosystem of the ant colony—in the nest, on

the foraging trails, and on and in the ants themselves—there are many niches that have been filled by thousands of adaptive animals.

Outside the nest, many insects and spiders attack and eat ants as they leave their homes, or pick them off while foraging. A number of insects steal the food from home-coming ant foragers.

Two prominent ant-eating insects are the ant lion and the wasp. Ant lions are insects that, when full grown, look like dragon flies. Their larvae are about a half-inch long and have six legs. They dig conical pits in sand or loose soil, and bury themselves at the bottom with only their mouths exposed. Insects, very often ants, fall into the pit and get eaten. Some wasps capture ants and sting them to paralyze them, but don't kill them. They place them live into cells in their hives where young wasps will hatch and eat the ants. There is one species of wasp that only feeds its young on fertile female ants.

HOUSE GUESTS

The most interesting enemies the ants face (from our point of view, not the ants') are those that live in the nest or on the ants themselves.

Ants' lives are plagued with an estimated 3,000 to 5,000 species of mostly unwanted house guests that range in size from microscopic to many times larger than the ants themselves. These pests are called *myrmecophiles**, which means "ant-loving," and are, for the most part, mites, spiders, worms, crustaceans, larvae of moths and flies, caterpillars, and many types of beetles.

An ant nest is dark, well-hidden, and temperature-controlled, and the ants chase away many potential enemies. Not to mention that ants leave lots of food lying around. And since ants instinctively act as nursemaids, and aren't very smart, they can be duped into taking care of other animals and their brood. All in all, it's a great place to live. If you're a parasite.

The things myrmecophiles find to eat include: bits of prey the ants bring into the nest; ant eggs, larvae, and pupae; adult ants (live or dead); the

discarded fiber from ants' infrabuccal pockets; and ant fecal matter. Some live just from licking the bodily secretions and salivary coatings off ants and their eggs. Some house guests can fool ants and give the proper signals to make the ants feed them through trophallaxis. Others move quickly and steal the food as it is being passed from one ant to another.

These "guests" have a number of ways of escaping the wrath or even the notice of their host ants. Some mimic the ants in color, shape, or smell, so ants think they are other ants. Some have venoms that repel attacking ants. Some are small and fast and can avoid the larger, slower ants. Some are shaped or armored so ants can't get a grip on them with their mandibles.

Many beetles use chemical propaganda to fool and manipulate ants. They emit secretions that ants like so much that they will protect the beetles and raise their brood (even though their brood eats the ants' brood). At least one species of beetle can emit chemicals that are so craved by ants that they get addicted and forget to take care of their own eggs and larvae. Other insects' larvae can produce odors that fool ant workers into thinking they are ant larvae, and so are fed.

The variety of myrmecophiles is too vast and too yucky to cover in detail in this book, but here's a few more:

Many mites and other parasites live directly on ants' bodies and suck their blood, or stroke their mouths and induce regurgitation, which they eat. When multiple mites attach themselves to one ant, they distribute their weight evenly on each side so the ant can keep its balance and continue to feed itself.

At least one species of fly lays its eggs in the queen ant's abdomen. The eggs hatch there and the pupae emerge from the queen. The queen dies, and the workers treat and care for the fly's larvae like their own.

There are spiders that live with army ants, and mimic them in color, smell, and their way of walking. Unlike other spiders, they have narrow

THAT'S NOT CRICKET ... OR IS IT?

waists that resemble the ants. They hide their extra pair of legs by waving them in front of them like antennae.

There are crickets that live with a number of species of ants. When they first approach an ant colony, they are attacked, but move quickly to escape. They keep returning until they absorb enough of the ants' colony odor that the ants will tolerate them. They also learn to mimic the way their host ants walk. When they are moved from a nest of slow-moving ants to a nest of fast-moving ants, they will change their way of walking.

OTHER ANIMALS

Amphibians, such as frogs and toads, eat so many ants that some scientists search frog stomachs to find out what kinds of ants live in that area. A number of new species of ant have been discovered this way. Reptiles, especially lizards, also eat ants.

Birds, especially woodpeckers, meadowlarks, roadrunners, and many tropical birds eat ants as a major part of their diet. Woodpeckers stick their tongues into ant nests and eat larvae and pupae. Other birds eat ants that they find on trees or on the ground.

Some birds do strange things with ants; this behavior, called "anting," takes two forms. Sometimes birds will sit near an anthill and allow the ants to crawl all over them. Other birds, notably crows, will chew up ants and rub them into their skin. It isn't really known why birds do this, but one theory is that it is recreational. The chemicals in the ants, including formic acid, may act as a stimulant or drug for the birds.

Anteaters, because of their name, are widely known as eaters of ants, but many of them really only eat termites. The ones that do eat ants have strong, powerful claws that they use to rip open ant nests. They have long sticky tongues that can follow twisting paths within the ant nests. The ants attack the tongue, and get stuck. The anteater pulls his tongue back into his mouth and scrapes off and swallows the ants. Anteaters can tightly close their ears, nostrils and eyes to protect them from angry, attacking ants.

Humans and their insecticides kill many ants, especially when the ants cause damage to crops or enter their homes. But ants have also been used by humans not only as food, but in medicines, cosmetics and religious rites.

CAMP FOLLOWERS

While not exactly enemies, many animals travel with or follow the trails of ants, especially army ants. Most take advantage of the commotion to increase their chances of finding food. They don't do noticeable harm to the ants, but they don't help them either.

"Antbirds" are birds of various species that follow army ants, eating any insects or arthropods that are stirred up by the passing army. "Antbutterflies" follow army ants, and eat antbird fecal matter.

THE HISTORY AND ORIGIN OF ANTS

The origin of ants is studied by examining fossil remains. Since ants are so small and delicate, not many rock fossils exist, but a number of ants were captured in amber* and preserved. These ants in amber date back to 50 million or more years ago. Amber is such a good preservative that in the best cases, the amber can be dissolved away and the 50-million-year-old ant can be studied directly.

Current thought on the origin of ants is that they have been around in roughly their present form for between 50 and 100 million years. In comparison, humans have been around for less than one million.

Ants are believed to have evolved from early non-social wasps. The earliest ant in amber is from the Cretaceous age of the Mesozoic period, and is about 100 million years old. Its petiole is ant-like, while its mandibles are wasp-like (very short, with only two teeth).

Ants, as a group, have changed very little physically over the eons. Of forty species of ants found in amber that was approximately 50 million years old, only thirteen were extinct species—the others are still alive and kicking today. Fossils have been found of a number of extinct species, but even the most primitive fossilized ant of all, *Prionomyrmex longiceps*, is very closely related to a number of living species.

Ants have changed physically over the years as they have evolved into different species that fit into different ecological niches all over the world, but their basic structure has remained the same. The most dramatic changes in ants have been in their behavior.

PRIMITIVE AND ADVANCED ANTS

Primitive ants are those most resembling the earliest ants, and therefore the non-social wasp from which they evolved. The more primitive ants hunt for their food—insects and other small animals. The most advanced ants herd aphids for food, or even grow their own fungus to eat.

PRIMITIVE TRAITS

Multiple queens in a single nest.
Spherical eggs that lie apart from each other on the nest floor.
The larvae are fed insect pieces.
The larvae can crawl short distances unaided.
Adults mostly eat plant nectar and collect meat (insects) to feed larvae.
Little or no recruitment among workers to go to food sources; little or no cooperation during foraging.
Slow and inefficient alarm communication.
Colony founding is only partially claustral.
When deprived of workers, nest queens can revert to colony founding behavior, including foraging above ground.
The queen and worker castes are very similar in size and form.
Single worker caste.
Small- to medium-sized nests, simply constructed.
Only adults groom the brood.
Workers do not lay trophic* eggs.
Workers do not assist larvae in spinning or emerging from cocoons.
Little or no nest odor recognition, little or no territorial behavior.
Inefficient or nonexistent transportation of adults by adults.

ADVANCED TRAITS

Single queens in a nest.
Ovoid eggs that lie grouped together on the nest floor.
Larvae are fed regurgitated food.
Larvae are immobile.
Adults eat anything.
When a worker finds food, it will recruit other workers to come and help bring it home.
Fast and efficient alarm communication.
Colony founding is completely claustral.
When deprived of workers, the nest queen just dies.
The queen and sterile worker castes are very distinct from each other.
Worker polymorphism—coexistence of two (or more) well-defined worker subcastes.
Fairly large nest, intricately constructed.
Adults groom each other as well as the brood.

Workers lay trophic eggs that are fed to workers and the queen.
Workers cover larvae with soil to aid in spinning cocoons, and assist new adults out of the cocoons.
Advanced nest odor recognition, and well-developed territorial behavior.
Adults can transport each other: one will hold very still while another carries it.

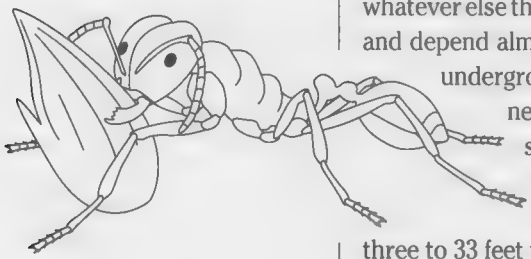
TYPES OF ANTS

With over 8800 species all over the world, the total variety of ants cannot be completely covered in this or any one book. The following is a sampling of some of the most common and some of the most interesting types of ants.

HERDERS

These ants were discussed in some detail earlier in this book in the Food section. These ants collect honeydew—a substance excreted by insects such as aphids and treehoppers, who feed on plant juices. Some ants simply lick fallen honeydew, whereas others "milk" the aphids and take it directly from the anal opening. In return for the food, the ants protect their herd from predators, and may even construct shelters over their "cows."

HARVESTER ANTS



Most ants supplement their diet with seeds. Some ants called "harvesters" feed primarily on seeds and supplement their diet with insects, fruit, and whatever else they can find. These ants usually live in arid environments and depend almost totally on seeds. Most harvesters build elaborate underground nests that can reach depths of six feet or more. The nests are sometimes covered with a mound of gravel and sand. In the nests are special chambers for storing seeds. Workers of some harvester species clear all vegetation in a circular radius around the nest, anywhere from three to 33 feet wide.

Some harvesters have very potent stings. Injecting only a hundredth of a milliliter of poison can cause humans much pain. A small drop of this poison can kill mice.

ARMY ANTS

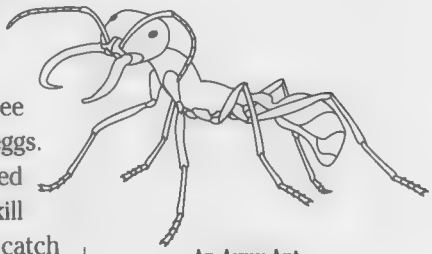
Army ants is a term used to describe the vicious, nomadic predator species of ants. The two most common types of army ants are the legionary ants of South America and the driver ants of Africa.

LEGIONARY ANTS

Legionary ants, found in tropical South America, hunt in groups large enough to kill animals many times their size. Unlike most ants, legionary ants do not build nests—they *are* their nests. They stay above ground

on the forest floor or in trees, and at night, they link their legs together to form a living nest around the queen and brood.

These ants spend their lives in two stages: the nomadic stage and the stationary stage. In the nomadic stage, the colony moves every day, carrying their brood, and hunting along the way. Each night they make camp and form their bodies into living nests called *bivouacs*.



An Army Ant

In the stationary stage, the colony stays at a bivouac for about three weeks while their wingless queen's abdomen swells and she lays eggs. While "camped," the workers go out on daily food raids, accompanied by soldiers. These ants will attack anything in their path, and can kill lizards, tarantulas and even birds. They chop up whatever they catch and bring it back to the bivouac.

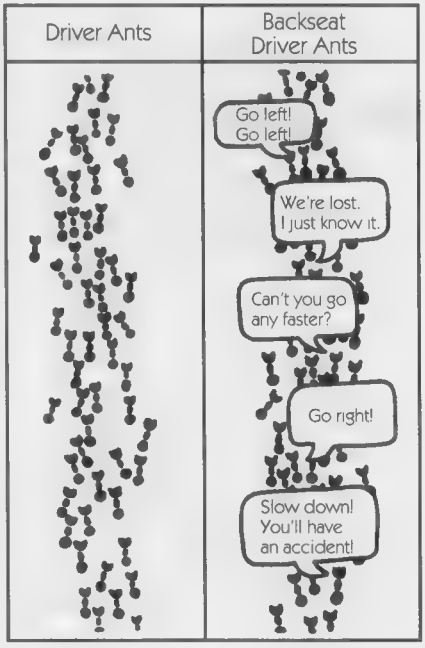
By the time the eggs hatch into larvae, the queen's body has shrunk, and the entire colony picks up and moves to a new location. When the larvae pupate, the colony stops again, and the queen lays more eggs.

DRIVER ANTS

Driver ants are found in Africa. Like legionary ants, they are mobile, but they dig nests in the ground where they stay for as long as three months, going on daily raids for food. When the colony moves, it takes several days. Driver ants can sometimes kill and eat animals as big as monkeys or pigs if they are trapped. Large animals and humans are only eaten by army (legionary or driver) ants in the movies.

Unlike the legionary ant queen, the driver ant queen's abdomen stays large the whole time, and she is less mobile.

ANT-THROPOLOGY



PARASITIC AND SLAVER ANTS

Some ants have entered into parasitic relations with other ants.

One type of parasitism is the compound nest, where two or more species of ant live together. The broods are maintained separately and the parasitic species obtains food from the host species. In another type of parasitic relationship, the mixed colony, the broods of the involved species are mixed and cared for as one. Some parasitic ants are permanent residents of the host colony and are so specialized that they have lost the worker caste.

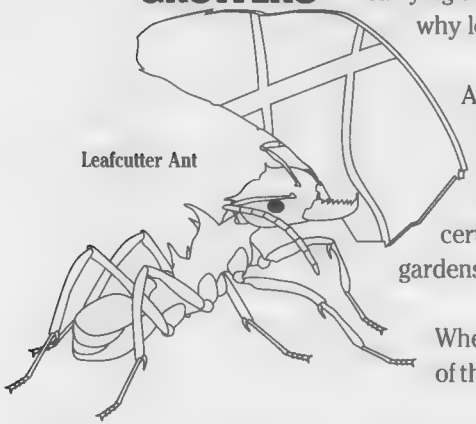
SOCIAL PARASITE

Slave-making also results in mixed colonies. Slave-making species raid other colonies and steal worker pupae that they enslave to carry out the work of their colonies. Some species, such as the Amazon ants of the genus *Polyergus*, are so specialized for capturing slaves that they can neither forage for themselves nor care for their young—without slaves they quickly perish.

LEAFCUTTER ANTS AND OTHER FUNGUS GROWERS

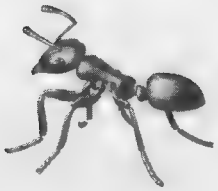
Leafcutters are the farmers of the ant world. They eat only a special kind of fungus that they grow underground.

Leafcutters have both large and small workers. The large workers go out, harvest, and bring back big leaves, flowers and pieces of plants. When carrying the leaves, it looks like the ant is carrying a parasol, which is why leafcutters are sometimes called parasol ants.


Leafcutter Ant

After the large workers bring the leaves into the nest, the small workers lick them and cut them up into tiny pieces. Then they chew the pieces to a pulp. The pulp is used as fertilizer and food for the fungus that the ants eat. Leafcutters only eat certain types of fungus, and any other types found in their gardens are weeded out.

When a winged leafcutter queen leaves the nest, she takes a piece of the fungus with her, in a pouch below her mouth. After she digs



her new nest chamber, she spits out the fungus, and cares for it along with her eggs. Her body produces a liquid that nourishes the fungus until her eggs hatch into workers that can gather leaves and plants to keep the fungus alive.

There are a number of fungus growers, other than leafcutters, that grow their fungus on various substrates* including dead grass, dead leaves, pieces of fruit, dead insects and even caterpillar and insect feces.

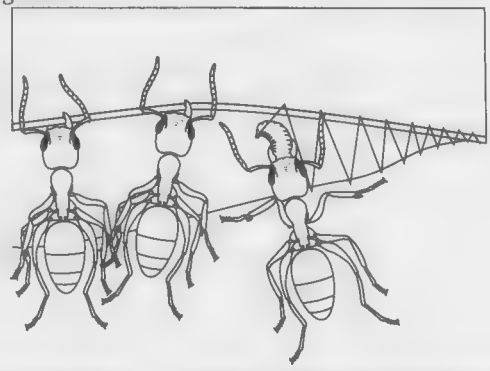
There is still much controversy as to the origin of the fungus farmers. Some believe that it was from bad housekeeping—mold growing on uneaten seed supplies. Others think it was from finding the fungus growing on feces from beetles or other wood-dwelling insects. Others believe that the ants may have begun feeding on the fungus that grew on their own feces.

WEAVER ANTS

Weaver ants are found in Africa, India and Australia (and a few other places). They are fairly large (up to 8 mm in length), live in trees and cause a lot of pain when they bite. The amazing thing about them is that they work in huge cooperative groups to make their nests in the trees.

Hundreds of these ants make chains of their bodies that span large leaves. They pull together to bend the leaves into shape, then sew the leaves together. They use the silk that their larvae make to weave their cocoons for thread. Workers hold nearly mature larvae in their mandibles, and move them from leaf to leaf, touching the larvae's mouths to the leaves, leaving a trail of sticky silk that binds the leaves together.

Weavers are so vicious that they are hard to study. Just bumping branches near their nests will incite thousands of biting ants to throw themselves onto you.



THIEF ANTS

There are a number of species of ants that are considered thieves. The most advanced species of thief ant is the *Carebara.* The workers of the Carebara are very tiny. They make small tunnels from their nests to the brood chambers in the nests of other species. They dart out of their small tunnels, and grab food, usually the eggs or larvae of their victims, and then run back into their tunnels that are too small for the victims to enter.

The *Carebara* species, in spite of the small size of the workers, has very large queens and males. The workers are so tiny compared to the queens, that when fertile females make their mating flights, a number of workers attach themselves to their feet, go along for the ride, and help found the new colony.

OTHERS

GOVERNMENT ANTS

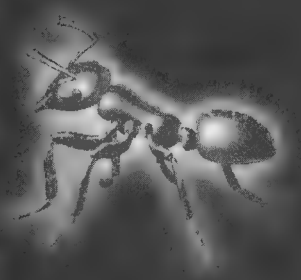
A new species of ant, *Pheidole fullerae,* was recently found in the Washington D.C. offices of the World Wildlife Fund.

ANT BOMBS

All ants have mandibular glands that produce mixtures of alcohols, aldehydes and ketones, used in very small quantities for sending signals to other ants for defense or alarm. The *Camponotus saundersi,* an ant found in Malaysia, stores these chemicals in a large sac in its abdomen. During battle, these ants can burst this sac and spray the enemy with these chemicals.

PART 3
BEYOND ANTS — *ANT*CILLARY MATERIAL

SIMANT



The biology of ants is about the history of societies and institutions, and about the future of cities and computers.

— Kevin Kelly

Ants are so omnipresent, such a inescapable part of life on earth, that they have infested our lives, our houses, our myths, fables, literature, movies and thoughts. Here's a spattering of stuff about ants.

ANTS AND HUMANS

Today we think of ants primarily as pests, but through the ages, ants have played many useful roles for human societies.

ANTS AS FOOD

Some humans eat ants. South American natives eat fertile, winged female fungus-growers, raw or toasted. In Africa, *Carebara* queens are eaten raw or cooked. California Indians have been known to eat the larvae and adult carpenter ants; they bite off and throw away the heads and swallow the bodies.

Honey ants (repletes) are considered a delicacy in parts of Australia, North America and Mexico. Usually just the honey-containing gaster is eaten. Some people in Mexico have fermented honey ants to make an alcoholic drink.

At one time ants were allegedly distilled with rye to "enhance" the flavor of cheap brandy.

ANTS AS MEDICINE

Ants have been used for medicinal purposes. In the Middle Ages, "oyle of antes egges" was used as a cure-all. More recently, crushed Formica ants were used in medicines for rheumatism and gout. In the past, lumbermen in Maine were said to eat wood ants to prevent scurvy.

As far back as 1000 B.C. and even today in many parts of the world, ants have been used as sutures for closing incisions. A live ant is held so it bites across the opening, pulling it together and holding it closed. Then the ant's body is pulled off the head, and the head is left there until the wound heals.

ANTS AND RELIGIOUS RITES

Ants have been used in religious rites, especially by South American Indians in Guiana. Ants were placed on children when they neared the

age when they should begin walking to "stimulate" them to walk. Men of the tribe would let ants bite their chests before going out on a hunt. Both men and women underwent a premarital ceremony where biting ants were placed on their heads, hands, and feet.

Some Indians of Central and South America placed army ants on their tribespeople as a part of initiation or puberty rites.

ANTS AS TOOLS OF PUNISHMENT

At least one African tribe has been reported to punish unfaithful wives by tying them to trees near nests of stinging and biting ants.

And, at least in the cowboy movies, Indians buried their enemies up to their necks near anthills.

A STRANGE BUT TRUE STORY

Our Manufacturing Manager's wife claims that as a little girl growing up in Texas, she used to sit on anthills and tease the ants. They would crawl all over her, bite her, then shrivel up and die. Her mother vouches for her. Her husband has been very careful about nibbling on her since he heard this story.

SimAnt
ANT QUOTES

Ants are so much like human beings as to be an embarrassment. They farm fungus, raise aphids as livestock, launch armies into war, use chemical sprays to alarm and confuse enemies, capture slaves, engage in child labor, and exchange information ceaselessly. They do everything but watch television.

— Lewis Thomas, *The Lives of a Cell*

The biology of ants is about the history of societies and institutions, and about the future of cities and computers.

— Kevin Kelly

They taste salty.

— Cassidy Wright

Go to the ant, thou sluggard, consider her ways and be wise:
Which having no guide, overseer, or ruler,
Provideth her meat in the summer and gathereth her food in the harvest.

— *Proverbs* 6:6–8

Not so much the weight of an ant in earth or heaven escapes from the Lord, neither is aught smaller than that, or greater, but is clearly written in God's book.

— *The Koran* 10:16

Th' old story iv th' ant an' th' grasshopper—th' ant that ye can step on and' th' grasshopper ye can't catch.

— Dunne

An active field of science is like an immense anthill; the individual almost vanishes into the mass of minds tumbling over each other, carrying information from place to place, passing it around at the speed of light.

— Lewis Thomas

The ant's a centaur in his dragon world.
Pull down thy vanity, it is not man
Made courage, or made order, or made grace,
Pull down thy vanity, I say pull down.
Learn of the green world what can be thy place
In scaled invention or true artistry,
Pull down thy vanity,
Paquin pull down!
— Ezra Pound

He remembered the belligerent ants, who claimed their boundaries, and the pacific geese, who did not...
— T.H. White, *The Once and Future King*

it wont be long now it wont be long
man is making deserts of the earth
it wont be long now
before man will have it used up
so that nothing but ants
and centipedes and scorpions
can find a living on it
— Donald Robert Perry Marquis

Forbear thou great good husband, little Ant;
A little respite from they flood of sweat;
Thou, thine own horse and Cart, under this Plant
Thy spacious tent, fan thy prodigious heat;
Down with thy double load of that one grain;
It is a Granarie for all thy Train.

Cease large example of wise thrift a while
(For thy example is become our law)
.....
Austere and Cynick: not one our t'allow
To lose with pleasure what thou gotst with pain.
— Richard Lovelace

Whence we see spiders, flies, or ants entombed preserved forever in amber, a more than royal tomb.

— Francis Bacon, *Historia Vitae et Mortis*

Here while I lie beneath the walnut bough,
What care I for the Greeks or for Troy town,
If juster battles are enacted now
Beneath the ants upon this hummock's crown?

— Henry David Thoreau

As a thinker and a planner the ant is the equal of any savage race of men; as a self-educated specialist in several arts she is the superior of any savage race of men; and in one or two high mental qualities she is above the reach of any man, savage or civilized.

— Mark Twain, *What is Man?*

While an ant was wandering under the shade of a tree of Pha'ton, a drop of amber enveloped the tiny insect; thus she, who in life was disregarded, became precious by death.

— Martial: *Epigrams* Book 6

Ants have bile and flies have spleen.
[In original Latin: *Formicæ sua bilis inest, habet et musca splenum.*]

— Sir Thomas Browne, *Pseudodoxia Epidemica*

The ant herself cannot philosophize—while man does that, and sees, and keeps a wife, and flies, and talks, and is extremely wise.

— Julian Huxley, *A Book of Essays*

None preaches better than the ant, and she says nothing.

— Benjamin Franklin, *Poor Richard's Almanac*

Ants do not bend their ways to empty barns, so no friend will visit the place of departed wealth.
[In original Latin: *Horrea formicæ tendunt ad inania nunquam Nellus ad amissas ibit amicus opes.*]

— Ovid, *Tristia* Book 1

We'll set thee to school to an ant, to teach thee there's no labouring i' the winter.

— Shakespeare, *King Lear* act 2, scene 4

Sometimes he angers me
With telling me of the moldwarp and the ant,
Of the dreamer Merlin and his prophecies,
And of a dragon and a finless fish,
A clip-wing'd griffin and a moulten raven,
A crouching lion and a ramping cat,
And such a deal of skimble-skamble stuff
As puts me from my faith.

— Shakespeare, *Henry IV* act 3, scene 1

Even as the tiny, hard-working ant drags all she can with her mouth, and adds it to the heap she is building, because she is not heedless of the morrow.

— Horace, *Satires* Book 1

To her hurt the ant got wings.

— Cervantes, *Don Quixote*

The age of great men is going; the epoch of the ant-hill, of life in multiplicity, is beginning.

— Amiel, *Journal,* 6 Sept. 1851

This many-headed, divers-armed, and furiously-raging monster is man; wretched, weak and miserable man: whom, if you consider well, what is he, but a crawling, and ever-moving ant's-nest?

— Montaigne, *Essays* Book 2, Chapter 12

Cicala to cicala is dear, and ant to ant,
And kestrels dear to kestrels, but to me
The Muse and song.

— Theocritus, *Idylls* 9

An ant is a wise creature for itself but it is a shrewd thing in an orchard or garden.

— Francis Bacon, *Of Wisdom for a Man's Self*

The ant, as Clarence Day had said, is a monkey's idea of industriousness. Its furious aimlessness and busy and bossy inefficiency so resemble "administrative talent" that we have accepted the ant as the type of admirable energy.

Nothing, actually, would be worse for a sluggard than to contemplate ants. Their small accomplishment for so enormous an expenditure of energy would reconcile him to his own indolence. Their infatuation for an indulgence of their parasites would lead him to parasitism. The only thing he might admire would be their thieving and their periodic orgies, the most wasteful saturnalias in nature.

— Bergen Evans, commenting on the Proverb
"Go to the ant, thou sluggard; consider her ways and be wise."

ANT FABLES, MYTHS, AND LEGENDS

These are quick summarized versions of the stories.

AESOP'S FABLE: THE PHILOSOPHER, THE ANTS AND MERCURY
A philosopher stood on the shore and witnessed a shipwreck where all the crew and passengers drowned. He protested aloud to Providence for His unfairness in killing so many innocent people. He soon realized that he was standing near an ant nest, for one stung him. He got mad and trampled all the ants to death. Then Mercury appeared and struck him, and basically told him to practice what you preach.

AESOP'S FABLE: THE ANTS AND THE GRASSHOPPER
During the winter, a hungry grasshopper asked some ants for some food. The ants asked him why he didn't store up food during the summer so he wouldn't be hungry now. He told them he was too busy singing to gather food. They said, "Starve, you lazy bum."

THE ANT WHO MARRIED A MOUSE
An ant found a penny and bought herself a ribbon. She put it on and sat in the window, watching the passersby. Many animals asked for her hand, and she chose the mouse, because she liked the way he sang. But the mouse fell into the stewpot and was killed.

A DOVE SAVES A DROWNING ANT
An ant was carried away by a stream. A dove dropped him a twig, and he rescued himself. Later, a hunter came with a trap to capture the dove. The ant stung his foot, making him drop his trap, and the dove was saved.

STRONG, STRONGER, AND STRONGEST
An ant broke its leg in the snow and brought suit. The judge condemned the snow for considering itself so mighty. The snow answered that the sun was mightier still, for it could melt snow. The sun replied that the cloud was mightier still, for it could cover the sun. The chain continues with the wind blowing the cloud, a wall stopping the wind, a mouse gnawing the wall, a cat chasing the mouse, etc., until it reaches God, the mightiest of all.

THE ANT'S BURDEN

A man asks a dwarf to make it rain on his crops. The dwarf tells the man to hit him (the dwarf) with small sticks. It works, and his crops grow. The man's father goes to the dwarf to do the same for his fields. He hits the dwarf with really big sticks, thinking he'll get that much more rain, and accidentally kills the dwarf. The dwarf was the King's jester, and the King orders the father to carry the dwarf in a box on his head until someone willingly takes it from him. He tricks an ant into taking the load, and thus the ant must permanently carry a burden.

SOUTHERN CALIFORNIA INDIAN LEGEND

A tribe of Indians from Southern California (I haven't been able to track down the tribe; if you know, please write and tell us) has a legend that claims the land itself is made out of ants. If you doubt it, just dig into it, and you'll find them there.

ANT FOLKLORE (AMERICAN)

If you sweep the floor on Ascension Day, you'll get ants in the house.

If ants are seen in your house on Christmas, it is a sign that bad luck will come to that household.

To step on an ant is bad luck.

When camping out, wear protection in your ears, or ants will build their nests in them and you'll go insane.

If you see a red ant and a black ant fighting, and the red ant wins, then you will win any challenge you attempt.

If you step on an ant, it will rain within the next day.

If you kill seven ants in a row, there is sure to be rain.

To cure warts, rub a piece of fat meat on it, and throw the meat to the ants.

If you find ants in your house, it is a sign you will move.

If you have ants in your kitchen, put coffee grounds outside the kitchen steps to kill them.

If ants are bothering you, draw a chalk line and the ants won't cross it.

When you see the ground all torn up by ants in the morning, you will know that summer has begun.

ANT- AND SUPERORGAN-ISM-RELATED MOVIES, BOOKS, SOFTWARE, ETC.

MOVIES, STAGE & TV

THEM

The classic 1950s science fiction film of science run amok and creating giant mutant ants.

EMPIRE OF THE ANTS

A movie with giant ants that live in the Everglades, take over a town and brainwash the people.

PHASE IV

A movie where lots of different ant species cooperate and get smart. An entomologist notices, and builds a research station to study them, but the ants take over.

UNDER THE SYCAMORE TREE

Written in 1952 by Samuel Spewack, this is a play where ants learned to talk. They became worried about humans destroying the earth so they made a short-wave transmitter and receiver to talk to the president of the United States.

THE HELSTROM CHRONICLES

A factual account of the potential rivalry between humans and insects for domination of the earth.

OTHER

Monty Python did a skit about a pet store that sells ants. It wasn't a very successful store.

POETRY

"DEPARTMENTAL"

Robert Frost wrote this poem about the burial of an ant. It features a dead ant named Jerry McCormick (no relation to Justin McCormick, one of the co-designers of SimAnt—at least not that we know).

"ANTS CRAWL MY DRUNKEN ARMS"

by Charles Bukowski

ANT VIDEOS

Ants: Backyard Science, National Geographic Society (11 min.)
Ants: Hunters and Gardeners, National Geographic Society (11 min.)
Amazing Ants, Coronet Films (11 min.)
The Ant and the Aardvark, MGM/UA Home Video (Cartoon. 32 min.)
The Ant and the Dove (Aesop fable), Coronet Films (Cartoon. 8 min.)
The Ant and the Grasshopper (Aesop), Coronet Films (Cartoon. 11 min.)
The Ant and the Grasshopper, Phoenix/BFA Films (Cartoon. 11 min.)
Ant Life, International Film Bureau (17 min.)
Ant World, Pyramid Film and Video (15 min.)
Army Ants: A Study in Social Behavior, Brittanica Films (19 min.)
Life Story of a Social Insect, Brittanica Films (11 min.)
In Search Of: Deadly Ants, Pyramid Film and Video (24 min.)

BOOKS AND STORIES

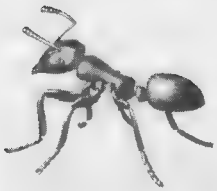
Ender's Game by Orson Scott Card
A masterful award-winning novel that combines computer games, adventure and intelligent "hive-minded" insects. Wonderful.

Sand Kings by George R. R. Martin
A very scary story about alien social insects. Hugo winner.

Blood Child by Octavia E. Butler
A Hugo-winning short story about intelligent insects and their relations with humans. Read it.

Morrow's Ants by Edward Hyams
A novel about a captain of industry who studies ants, and from what he learns builds a huge, partly underground factory and human colony that works quite well. He controls the humans' behavior with pheromones in the air and food.

The Ants Who Took Away Time by William Kotzwinkle
A tribe of giant ants steal the Great Timepiece and cause time to stand still.



Two Bad Ants by Chris Van Allsburg
Two bad ants desert their colony, experience a dangerous adventure and return home.

The Sword in the Stone by T.H. White
There is a scene where Arthur gets turned into an ant by Merlin for a lesson in life.

The Author of the Acacia Seeds by Ursula K. LeGuin
A short story about how ants communicate by arranging acacia seeds and begin an ant revolution.

Bug House by Lisa Tuttle
A horror story about a house with some very unusual occupants.

SOFTWARE

"It Came From the Desert"
A CinemaWare Adventure game based on the movie *Them.*

"Ant21"
A shareware program from Autodesk, Inc. for IBMs and compatibles that lets you evolve ants that move in different patterns. It's like breeding art.

MUSIC SCORE:

Anthem for Ants by Aulis Sallinen

ANTS AND THE STUDY OF ARTIFICIAL LIFE

Ants, because of their individually simple behavior and the resulting very complex group behavior, have become the "mascots" of the Artificial Life branch of computer science.

WHAT IS ARTIFICIAL LIFE?

To quote Christopher Langton, co-organizer of the A-Life conferences: "Artificial Life is the study of man-made systems that exhibit behaviors characteristic of natural living systems. It complements the traditional biological sciences concerned with the analysis of living organisms by attempting to synthesize lifelike behaviors within computers and other artificial media."

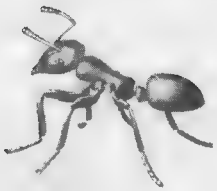
A-Life isn't a bunch of computer scientists trying to exercise the power of life and death over their creations (well, maybe just a little...); it's a whole new way to study biology, evolution, and life. It's a complete laboratory in a computer.

An advantage to experimenting with A-Life (as opposed to "real life") is the ease with which you can make exact changes to the environment or to the life-form itself during experiments. It also eliminates many moral issues involved with animal experimentation—at least for a number of years. (Check out *The Seventh Sally* by Stanislaw Lem, a story that poses the question, "How real does an artificial life-form have to appear before it *is* real?" For that matter, check out the character Data on *Star Trek: The Next Generation.* There was an episode exploring this very topic.)

One highly-publicized (and much disliked) type of A-Life is the computer virus: a self-replicating electronic beastie that lives in computers.

The future of A-Life holds much potential and promise. It may someday go beyond the experimental world into the practical realm of design. The tools and techniques being developed now will someday allow us to grow or evolve designs for complex systems ranging from software to airplanes.

In a sense, A-Life has the same goals as Artificial Intelligence (AI), but uses opposite methods. AI is the top-down approach to creating a



thinking machine that emulates the human brain. A-Life is the bottom-up approach—start with single cells and grow/evolve intelligence.

ARTIFICIAL LIFE MASCOTS

The "key" concept in A-Life is emergent behavior—the complex resulting behavior that emerges from the combination of many individuals exhibiting simple behaviors. Ants are a perfect example of emergent behavior, and for that reason have become the unofficial "mascots" of A-Life. In the recent second Artificial Life Conference, there were quite a number of artificial worlds that used ants or ant metaphors for the main inhabitants.

ARTIFICIAL LIFE AND COMPUTER GAMES

All of Maxis' simulation games (SimCity, SimEarth, SimAnt, etc.) are at least partially based on A-Life concepts and techniques. We will continue to use and explore the latest methods and discoveries in A-Life in our future games.

ANT COLONIES AS MODELS FOR COMPUTERS AND BRAINS

An ant colony is a highly redundant, fault-tolerant system that is capable of a high degree of specialization—remarkably like a brain. Because of this, a number of theorists have compared the working of an ant colony to the working of a thinking brain.

"ANT FUGUE"

by Douglas Hofstadter

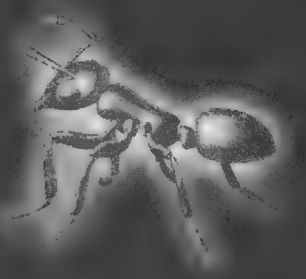
Douglas R. Hofstadter, in his Pulitzer Prize–winning book ***Godel, Escher, Bach: An Eternal Golden Braid***, uses an ant colony, referred to as Aunt Hillary, as an analogy for how the human brain works. He proposes that individually, ants are not endowed with intelligence, but as a whole, the colony is.

His human parallel is that an individual neuron in a human brain is not in and of itself intelligent, but together, a few billion brain cells can carry on an intelligent conversation. He makes further analogies comparing working groups and castes of ants representing different levels of the organization of thought.

The scope of "Ant Fugue" goes far beyond the bounds of this book and beyond my ability to summarize without butchery. As part of *Godel, Escher, Bach,* it deals with the philosophy of mind and thought, and is worth reading even if you don't like ants.

PART 4
GLOSSARY, BIBLIOGRAPHY AND INDEX

SimAnt



None preaches better than the ant, and she says nothing.

— Benjamin Franklin,
Poor Richard's Almanac

Altruism — behavior by an animal that is not beneficial or may be harmful to itself but that benefits the survival of its species.

Amber — a hard yellowish to brownish translucent fossil resin that takes a fine polish and is used chiefly in making ornamental objects. Often the source of well-preserved fossil remains.

Arthropods — any of a phylum (*arthropoda*) of invertebrate animals (as insects, arachnids, and crustaceans) that have a jointed body and limbs, usually a chitinous shell molted at intervals, and the brain dorsal to the alimentary canal and connected with a ventral chain of ganglia.

Associative Learning — a learning process in which discrete ideas and percepts become linked to one another.

Biology — a branch of knowledge that deals with living organisms and vital processes; also, the plant and animal life of a region or environment.

Biomass — the weight of all the living organisms in a given population, area, or other unit being measured.

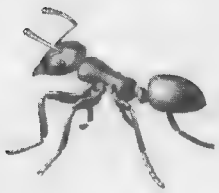
Brood — the immature members of a colony collectively, including eggs, nymphs, larvae, and pupae. In the strict sense, eggs and pupae are not members of the society, but they are nevertheless referred to as part of the brood.

Callows — newly eclosed adult workers whose exoskeleton is still relatively soft and lightly pigmented.

Caste — any set of individuals of a particular type or age group, or both, that performs specialized labor in the colony. More narrowly defined, any set of individuals in a given colony that is both morphologically distinct and specialized in behavior.

Chitin — a tough, resistant, nitrogen-containing polysaccharide that forms the cell walls of certain fungi, the exoskeleton of arthropods, and the epidermal cuticle of other surface structures of certain other invertebrates.

Claustral — the procedure of colony founding during which queens (or in the case of termites, royal pairs) seal themselves off in cells and rear the first generation of workers on nutrients obtained mostly or entirely from their own storage tissues, including fat bodies and histolysed wing muscles.



Cocoon — the protective covering of a resting or developmental stage, sometimes used to refer to both the covering and its contents.

Eclose — to emerge as an adult from the pupa; less commonly, the hatching of an egg.

Entomology — a branch of zoology (the branch of biology concerned with the animal kingdom) that deals with insects.

Evolution — change in the genetic makeup of a population with time.

Exocrine Glands — a type of gland that releases its secretion through a duct, such as digestive glands and sweat glands; contrasts with *endocrine*.

Exoskeleton — an external supportive covering of an animal (as an arthropod).

Female-calling Syndrome — the release of sexual attractants by a reproductive female who stands in one place and "calls" males to come to her.

Funiculus — all of the antenna except the first segment, or scape.

Gaster — a special term occasionally applied to the metasome, or terminal major body part, of ants.

Habituation — a form of learning often involving a diminishing response to a repeated stimulus or the ignoring of an often-repeated stimulus.

Homeostasis — the maintenance of a steady state, especially a physiological or social steady state, by means of self-regulation through internal feedback responses.

Hygroscopic — readily taking up and retaining moisture; taken up and retained under some conditions of humidity and temperature.

Imprinting — a rapid learning process that takes place early in the life of a social animal and establishes a behavior pattern, such as recognition of and attraction to its own kind or a substitute.

Initiators — ants that recruit other ants to forage, defend or attack.

Instar — any period between molts (the casting of the outgrown skin or exoskeleton in the process of growth) during the course of development.

Instinct — stereotyped, predictable, genetically programmed behavior. Learning may or may not be involved.

Male-aggregation Syndrome — the mating pattern in which males from different nests gather in a group and queens join them to be inseminated.

Microclimate — the essentially uniform local climate of a usually small site or habitat.

Minims — a minor worker, especially the smallest worker of the kind typically seen in founding colonies or at the low end of size variation of strongly and continuously polymorphic species.

Monogynous — existing with only one functional queen in the nest. Primary monogyny: monogyny through the founding of the colony by a single queen. Secondary monogyny: monogyny through the elimination of multiple founding queens until only one is left.

Myrmecology — the scientific study of ants.

Myrmecophiles — organisms that must spend at least part of their life cycles with ant colonies.

Nanitics — the dwarf workers produced from either the first ant broods or late ant broods that have been subjected to starvation. Nanitic workers occur in both monomorphic and polymorphic species.

Nuptial Flight — the mating flight of the winged queens and males.

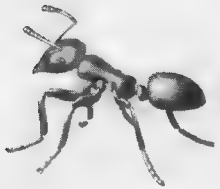
Operant Conditioning — conditioning in which the desired behavior or increasingly closer approximations to it are followed by a rewarding or reinforcing stimulus.

Partially Claustral — the procedure during which the queen founds the colony by isolating herself in a chamber but occasionally leaves to forage for part of her food supply.

Petiole — the first segment of the waist of insect groups including the bees, ants and many of the wasps. It is in fact the second abdominal segment, since the first abdominal segment (*propodeum*) is fused to the thorax.

Pheromones — a chemical substance or a blend of substances, usually a glandular secretion, which is used in communication within a species. One individual releases the material as a signal and another responds after tasting or smelling it. Primer pheromones alter the physiology of individuals and prepare them for new behavioral repertories. Releaser pheromones evoke responses directly.

Polygynous — coexisting in the same colony with two or more egg-laying queens. When multiple queens found a colony together, the condition is referred to as *primary polygyny*. When supplementary queens are added after colony foundation, the condition is referred to as



secondary polygyny. The coexistence of only two or several queens is sometimes called *Oligogyny.*

Polymorphic — in social insects, the coexistence of two or more functionally different castes within the same sex. In ants it is possible to define polymorphism somewhat more precisely as the occurrence of nonisometric relative growth occurring over a sufficient range of size variation within a normal mature colony to produce individuals of distinctly different proportions at the extremes of the size range.

Primer Effects — alterations of ant physiology caused by primer pheromones that prepare the ants for new behavior patterns.

Pupate — to pass through the pupal stage, an intermediate (usually quiescent) stage of a metamorphic insect that occurs between the larva and the imago, usually enclosed in a cocoon or case and undergoing internal changes by which larval structures are replaced by those typical of the imago.

Releaser Effects — ant behavior changes caused by releaser pheromones that evoke direct stimulus/response reactions.

Repletes — ants whose crops are greatly distended with liquid food, to the extent that the abdominal segments are pulled apart and the intersegmental membranes are stretched tight. Repletes usually serve as living reservoirs, regurgitating food on demand to their nestmates.

Scape — the shaft of an animal part, as an antenna or feather.

Semiochemicals — chemicals used in communication within or between species.

Social Homeostasis — the maintenance of steady states at the level of the society either by control of the nest microclimate or by regulation of the population density, behavior, and physiology of the group members as a whole.

Sociobiology — the comparative study of social organization in animals and man especially with regard to its genetic basis and evolutionary history.

Sociology — the science of society, social institutions, and social relationships; specifically, the systematic study of the development, structure, interaction, and collective behavior of organized groups of human beings.

Stridulation — the production of sound by rubbing one part of the body surface against another.

Substrates — the foundations to which organisms are attached; a molecule upon which an enzyme acts.

Superorganisms — any society, such as the colony of a eusocial insect species, possessing features of organization analogous to the physiological properties of a single organism. The insect colony, for example is divided into reproductive castes (analogous to gonads) and worker castes (analogous to somatic tissue); it may exchange nutrients by trophallaxis (analogous to the circulatory system); and so forth.

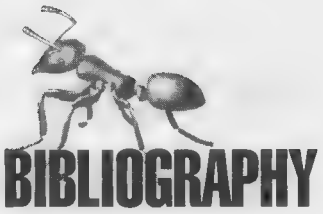
Symbiotic — the living together of dissimilar organisms in more or less intimate association or close union, often of a mutually beneficial nature.

Taxonomy — the classification of organisms on the basis of their evolutionary relationships.

Trophallaxis — the exchange of alimentary liquid food among colony members and guest organisms, either mutually or unilaterally. In stomodeal trophallaxis the material originates from the mouth; in proctodeal trophallaxis it originates from the anus.

Trophic Egg — an egg, usually degenerate in form and inviable, which is fed to other members of the colony.

Trunk Trails — the principle foraging trails laid out by repeated chemical release during food collection and return to the nest, significantly seen in army ants and driver ants.



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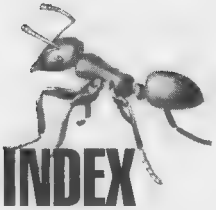

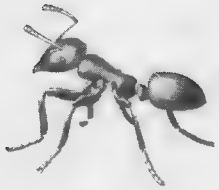

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